THE TELEGRAPHIC JOURNAL AND

Electrical Review.

VOL. XXI.—No. 520.

PRIMARY BATTERIES.

Once upon a time when electric lighting companies could be counted by scores there lived a man who one day awoke to find himself famous. He was hailed by many people, presumably sane, as a great discoverer, although what he discovered, excepting that the British public is easily gulled, remains a mystery to this day. Nevertheless, he invented a "system," and upon this foundation was reared a company. For a time he and his system shone as stars of the first magnitude, but their glory has long since gone away in the *ewigkeit*. The genius to whom this preamble refers will be recognised by "old timers" in electric lighting as he of "multiple terminal" fame, whose sudden rise to notoriety was due not so much to his own individual efforts, as to the outside help he received from ignorant and injudicious supporters.

It may occur to some to enquire what this has to do with primary batteries. The reason comes in right here.

Perhaps the warmest support and the strongest championship of the "multiple terminal" dodge came from Mr. Perry F. Nursey, who on Monday last read a paper on primary batteries. This gentleman's connection with *Iron* and the *Times* is well known, and he is a past president of the Society of Engineers—to a meeting of whose members his paper was presented.

We had expected to hear the subject treated in at least an able manner, but we can see little else in the hotch-potch before us but a re-hash of newspaper descriptions of the batteries which have appeared during the past four or five years. To republish the compilation would be but to encumber our pages with column upon column of matter which our readers would probably resent as an insult to their understanding, and we shall therefore content ourselves with pointing out a few "items of interest."

Mr. Nursey's contribution to the literature of voltaic batteries, the result of profound thought and deep study, was, he assures us in his conclusions, completed in less than three weeks. The earlier part of the paper is divided into sections, the first introductory, the next dealing with principles, and the third historical. Following these is the author's learned descriptions of some sixteen types of battery, including the Holmes-Burke, Ross, Lalande-Chaperon, Newton, "Regent," "Eclipse," D'Humy and others. The author lays down certain conditions as being requisite in batteries for general lighting, which, we may add, can be found in Prof. Silvanus Thompson's text-book on Electricity and Magnetism. We are then gravely informed that "the light," of whatever candle-power it may have been, from a Holmes-Burke battery was maintained for 24 hours at the average cost of one-eighth of a penny per light per hour, but—and here, by all that's wonderful, comes the crucial point—that *the expense varied with the size of the lamps and the amount of electricity used.*

A little further on we find the author struggling with a calculation based upon Ohm's law. We are told that the internal resistance of the sized cell generally used is 0·03 ohms. Consequently a discharge of 10 ampères can be obtained at an E.M.F. of 1·5 volts. We have tried hard, but in vain, to prove this statement, and we confess our inability to cope with the problem.

When dealing with the Ross battery Mr. Nursey again tells us that which we have so often heard, but which is still so far from the truth, that a consumption of zinc representing 2d. per hour will give us over 1⅓ horse-power. Why such absurdities as this should be seriously brought before a body of technical men is one of those things which ever remain incomprehensible. Furthermore we are told that the light, when produced from the Ross battery, is of *good quality!* The *naïveté* of this is delicious.

In speaking of the Pollak battery we are told that it was found wanting in practical use. The E.M.F. proved to be so small and the resistance increased so considerably with a number of cells that it had to be given up. Still, says our *savant*, as a novel and ingenious primary battery *it had its merits.* This puts us irresistibly in mind of the Irishman who laid a wager of 6d. with a comrade that the latter could not carry him up a ladder in a bricklayer's hod to the top of a six storey building without falling. The bet was accepted, and after much exertion and risk of an accident at every step, the Irishman was safely placed. Turning to his comrade the loser said, "Pat, ye fairly won the sixpence, but bedad when yez got three quarters of the way up *I had me hopes.*"

Prof. Silvanus Thompson is still inseparably associated with the "Eclipse," for the most favourable thing reported of it in Mr. Nursey's paper is the reproduction of that celebrated dictum "Dr. Silvanus Thompson says the battery will run for thirteen hours without being re-charged."

Mr. D'Humy, of course, comes in for the lion's share of the author's praise, and he finishes his peroration on the water battery in the following manner:—"by the light of Mr. D'Humy's installation the invention appears to possess points of ingenuity and merit." *By the light of Mr. D'Humy's installation. Ah! verbum sap.*

We could multiply these instances *ad nauseam*, but to what purpose? Simply to show what we have previously said. But we go further and unhesitatingly declare that Mr. Nursey's paper is utterly unworthy from any point of view of the transactions of the Society of Engineers. There is absolutely nothing in it which the readers of newspapers and technical journals are not already too well acquainted with; the data given are simply statements from people all more or less interested in the systems described; and several batteries, such as the Loeb, Schanschieff and Liepmann, are not even touched upon.

How any man who values his reputation can allow himself to be placed in the position of an authority upon a subject, the matter for which has been entirely compiled from the statements of interested persons, and which have already been the round of the daily Press, passes our comprehension.

Our readers need not to be told how unthankful a task it is to sift the chaff from the grain in questions relating to electrical inventions, so as to place the non-technical public upon its guard against worthless inducements for investment; but we have never faltered in what we considered our duty in protecting those upon whose support we rely. The batteries mentioned in Mr. Nursey's paper have almost without exception received due attention from us, and our strictures upon any or all of them have, we think, in every case been justified. We cannot conclude without entering a protest against the reading of such verbiage as that which, by courtesy, we will call a paper on primary batteries, but which in reality is a hashed up *mélange* of the senseless and misleading statements of others. We can only think that those gentlemen known to the scientific world, who took part in the discussion which we publish elsewhere, were impelled to speak with a view of gaining verbally that information of which the paper itself was utterly devoid.

THE result of the action, reported in another column, concerning damage occasioned by the breaking of a telephone wire, must have been a sad blow for the United Telephone Company, which was the defendant in the case. The question of damages was of minor importance compared with the wider consideration of the right to obtain an injunction against the running of wires over premises the owners or occupiers of which withhold their consent. A claim had been set up here for an injunction, but it was abandoned because the company had refrained from re-erecting the wire over the plaintiffs' premises; but the terms of the decision adjudging the defendant company liable for the damage done by the severe snowstorm of last December contained a clause which almost amounts to an admission that an injunction will lie in any case where it is attempted to erect a wire over buildings in opposition to the wishes of the occupiers. We cannot say that this is an unreasonable view to take of the matter, but all the same it will be a blow to the telephone company, which is often forced to the practice of running its wires in certain directions surreptitiously. It has tried, and we believe is still trying, to obtain compulsory powers, but there seems to be little likelihood of such powers being granted, and a decision which holds that a breaking telephone wire is capable of doing damage to the extent of £300, and that the company has no business to run its wires in such a position except by consent, is calculated to excite serious prejudices, and to increase the difficulties which the company has to encounter.

PROF. STOKES, the President of the Royal Society, aspires to take the place in Parliament vacated by the late Mr. Beresford Hope. We sincerely hope and we believe that the electors of Cambridge University will show their faith in the value to the national councils of a stronger leavening of real scientific worth. Education and ability are indispensable in the representative of a University, and Prof. Stokes possesses both qualifications in a high degree. He will, if elected, be a welcome addition to the none too numerous band of scientific men in Parliament — amongst the most notable of whom are Sir Lyon Playfair, who, Prof. Tyndall, notwithstanding, decidedly *does* count, in all matters relating to science and education at all events; Sir Henry Roscoe, the eminent chemist and warm supporter of the spread of scientific teaching; and Sir John Lubbock, whose versatility and geniality do not detract from the importance attaching to his utterances upon weightier matters than the habits of ants and bees. It is a matter of slight importance that these gentlemen are different in complexion in regard to party politics from the President of the Royal Society; we are thinking now, whatever may be our opinions upon national and fiscal questions, of science and its encouragement mainly, and the addition of one more eminent exponent of physical principles, whether he be Liberal or Conservative, Unionist or Separatist, is in our view a distinct gain to Parliament and to the nation. Prof. Stokes has issued a very plain, straightforward statement of his opinions to the members of the Senate, in which, however, he does not go far outside the few questions which appeal specially to the minds of members of the University.

AT the meeting of the Institution of Civil Engineers last Tuesday evening, Mr. G. B. Bruce, the president, delivered an address on assuming the chair for the first time since his election. Touching the position of the workmen 50 years ago and now, the President observed that in 1837 the wages of an engine-erector in Newcastle were 23s. per week, working 61 hours. In 1887 the wages were 32s. per week, working 54 hours; the resultant of these alterations was an increase in wages per hour of 57 per cent. Taking into consideration that the prices of nearly all the necessaries and the ordinary comforts of life, with the exception of English beef and mutton, were greatly less than they were in 1837, it was very clear that the position of the British mechanic had immensely improved during the reign of Queen Victoria, for though only one class of workman was dealt with, the same influences affected the whole. In regard to foreign competition, the President was emphatic. He said, "We are constantly told that the difficulty Britain has in holding its own in the markets of the world is due to our want of technical education. There is something in this, but, in my judgment, comparatively little. The true cause of the difficulty is the large increase of wages and the diminution in hours of labour. It would be pleasant to think that this was not so, but I have not the shadow of a doubt that it is the main cause of the difficulty in meeting foreign competition."

THE secondary battery which we described in our last issue, is said to cost much less than the cheapest battery in the market for the same output. Naturally, the electrodes may be made circular instead of square if thought desirable, and it will be seen that it is then built up just like the core of a dynamo armature. Buckling is said to be non-existent in these cells, and if any repairs are found necessary they can be very quickly carried into effect. Our description of the construction of the type illustrated was slightly erroneous, inasmuch that the square cylinder is made up of eight bolts with a top, bottom, and middle piece of cast lead.

THE INTERNATIONAL EXHIBITION, GLASGOW, 1888.

IT having been decided that this Exhibition should be lighted throughout with electricity, specifications have been prepared and issued, and tenders must be sent in not later than the 15th. It may be at once stated that there is no novelty in the plans adopted for electric lighting, arc and incandescent lamps worked direct from the dynamo being settled upon, the disposition and arrangement of the lamps being almost identical with the plan now in such successful working at the Royal Jubilee Exhibition, Manchester.

The following gives the details of how the lighting is to be carried out :—

Section 1.—Machinery in motion.—This section, which contains 78,000 square feet, is to be lighted by means of 93 arc lamps on at least three circuits.

Section 2.—This section, which embraces the courts on the north side of the Exhibition, 14 in number, is to be lighted with 104 arc lamps in four circuits.

Section 3.—Comprises the Main Avenue, Concert or Grand Hall, Dome, and Transverse Avenue, as also the 45-foot passage and three courts near the Machinery Annexe, containing about 112,500 square feet, will be lighted by 126 arc lamps, in at least four circuits.

Section 4.—Includes 20 courts on the south side of the Exhibition and also the East and West Corridors, and contains about 90,000 square feet.

Section 5.—Includes the 10 galleries set apart for the reception of pictures, and contains about 32,000 square feet, and will be lighted either by incandescent or arc lamps, as the committee may decide.

The number of lamps required for "incandescent lighting" will be 2,000 16-candle-power glow lamps of Swan-Edison or Anglo-American Brush manufacture, suspended from the roof and arranged in two rows in each gallery, or carried in electroliers. There are to be at least three circuits, having a maximum E.M.F. of 120 volts. The main leads and branch wires to be of the best insulation, equal to that known as ship quality, and having a guaranteed insulation of 100 megohms per 1,000 yards.

For "arc lighting" there will be required 40 arc lamps of the best construction, secured to the iron roof girders, and fitted with diffusing apparatus or screen running the entire length of each gallery to hide the source of light from the eye. All globes to be covered with wire netting, and extra precautions to be taken that no pieces of carbon can fall from the lamp.

Section 6.—This section, which embraces the Refreshment and Dining Rooms, contains about 30,000 square feet, will be lighted by means of 750 to 800 16-candle-power glow lamps, carried on roof principals, or suspended by silk cord, and securely held in coloured glass shades.

Section 7.—Grounds and Promenade.—The general lighting of the gardens and grounds will be by means of 70 arc lamps. "Contractors should quote for 15 to 18 masts of 60 80 feet in height, with efficient raising and lowering gear for three lamps on each. The remainder of the lamps to be carried on short poles disposed among the trees."

The arc lamps are required to have carbons of 11 mm. diameter and a current of 10 ampères passing through them. In each section the various circuits are to be arranged with a spare dynamo, and adjacent lamps are required to be on different circuits.

The "General Conditions" require that the Picture Galleries shall be in readiness by the 15th day of March, and the buildings and grounds on or before the 31st day of March. "All tenders are to be given in a net sum for 600 hours' lighting, and a rate per lamp per hour to be given for extra lighting, including installation." A test run of six consecutive hours under full head will be required, to show that there is no excessive heating.

The exhibitors can obtain any necessary light they may wish, which will be supplied by the executive, the contractors not being allowed to supply any, but they are required for this purpose to have a reserve dynamo power of at least 15 per cent. of their entire installation.

The conductors are to be calculated on the basis of 1,000 ampères to the square inch.

The executive will provide engine-power and shafting, with pulleys of such size as may be required, but no belting for the dynamos.

Disputes as to the proper meaning of the specification to be referred to Sir William Thomson, failing whom, Mr. W. H. Preece.

As we have already announced, Mr. W. A. Bryson, the electrician to the Royal Jubilee Exhibition, Manchester, has been appointed to the similar position at the International Exhibition, Glasgow, and he will take up his appointment immediately on the closing of the former on the 10th inst. Mr. Bryson, who is also engineer to the Exhibition and has entire charge of the Machinery Annexe, has prepared this Glasgow specification upon somewhat similar lines to the plans which have worked so well at Manchester. As the building and grounds are, in both cases, arranged in much the same way a likeness of plans is inevitable. The number of arc lamps will be 501, and of incandescent, 2,800, in each case somewhat lower than at Manchester. There are three dynamo rooms in the Glasgow Exhibition, situated next to the Machinery Annex and boiler rooms; these are situated at the greatest possible distance, about 1,500 feet, from the Picture Galleries, where the largest number of incandescent lamps are placed.

If the specified arrangements be carried out in a similarly excellent manner to those at the Manchester Exhibition, there is every reason to expect that the electric lighting will be quite as conspicuous for the satisfactory nature of the light and its perfect reliability.

MODERN VIEWS OF ELECTRICITY.*

By PROF. OLIVER J. LODGE, in *Nature*.

PART II.—CURRENT ELECTRICITY (*continued*).

IV.

Electrical Inertia.

RETURNING now to the general case of conduction, without regard to the special manner of it, we must notice that, if a current of electricity is anything of the nature of a material flow, there would probably be a certain amount of inertia connected with it, so that to start a current with a finite force would take a little time; and the stoppage of a current would also have either to be gradual or else violent. It is well known that if water is stagnant in a pipe it cannot be quite suddenly set in motion; and again, if it be in motion, it can only be suddenly stopped by the exercise of very considerable force, which jars and sometimes bursts the pipe. This impetus of running water is utilised in the water ram. It must naturally occur, therefore, to ask whether any analogous phenomena are experienced with electricity; and the answer is, they certainly are. A current does not start instantaneously: it takes a certain time—often very short—to rise it to its full strength; and when started it tends to persist, so that if its circuit be suddenly broken, it refuses to stop quite suddenly, and bursts through the introduced insulating partition with violence and heat. It is this ram or impetus of the electric current which causes the spark seen on breaking a circuit; and the more sudden the breakage the more violent is the spark apt to be.

The two effects—the delay at making circuit, and the momentum at breaking circuit—used to be called "extra-current" effects, but they are now more commonly spoken of as manifestations of "self-induction."

We shall understand them better directly; mean-

* Expansion of a lecture delivered by Dr. Oliver Lodge, partly at the London Institution on January 1st, 1885, and partly at the Midland Institute, Birmingham, November 15th, 1886, but not hitherto published.

while they appear to be direct consequences of the inertia of electricity; and certainly if electricity *were* a fluid possessing inertia it would behave to a superficial observer just in this way.

But if an electric current really possessed inertia, as a stream of water does, it would exhibit itself not only by these effects, but also mechanically. A conducting coil delicately suspended might experience a rotary kick every time a current was started or stopped in it; and if a steady current were maintained in such a coil it should behave like a top or gyrostat, and resist any force tending to deflect its plane.

Clerk Maxwell has carefully looked for this latter form of momentum effect, and found none. One may say, in fact, that nothing like momentum has yet been observed in an electric current by any *mechanical* mode of examination. A coil or whirl of electricity does not behave in the least like a top.

Does this prove that a current has no momentum? By no means necessarily so. It might be taken as suggesting that an electric current consists really of two equal flows in contrary directions, so that mechanically they neutralise one another completely, while electrically—*i.e.* in the phenomena of self-induction or extra current—they add their effects. Or it may mean merely that the momentum is too minute to be so observed. Or, again, the whole thing—the appearance of inertia in some experiments and the absence of it in others—may have to be explained in some altogether less simple manner, to which we will proceed to lead up.

Condition of the Medium near a Circuit.

So far we have considered the flow of electricity as a phenomenon occurring solely inside conductors; just as the flow of water is a phenomenon occurring solely inside pipes. But a number of remarkable facts are known which completely negative this view of the matter. Something is no doubt passing along conductors when a current flows, but the disturbance is not *confined* to the conductor; on the contrary, it spreads more or less through all surrounding space.

The facts which prove this have necessarily no hydraulic analogue, but must be treated *suorum generum*, and they are as follows:—

(1). A compass needle anywhere near an electric current is permanently deflected so long as the current lasts.

(2). Two electric currents attract or repel one another, according as they are in the same or opposite directions.

(3). A circuit in which a current is flowing tends to enlarge itself so as to inclose the greatest possible area.

(4). A circuit conveying a current in a magnetic field tends either to enlarge or to shrink or to turn half round according to the aspect it presents to the field.

(5). Conductors in the neighbourhood of an electric circuit experience momentary electric disturbances every time the current is started or stopped or varied in strength.

(6). The same thing happens even with a steady current if the distance between it and a conductor is made to vary.

(7). The effects of self-induction, or extra currents, can be almost abolished by twisting the covered wire conveying the current closely on itself, or even by laying the direct and return wire side by side; whereas they may be intensified by making the circuit inclose a large area, more by coiling it up tightly into close coils, and still more by putting a piece of iron inside the coil so formed.

Nothing like any of these effects is observable with currents of water; and they prove that the phenomena of the current, so far from being confined to the wire, spread out into space and affect bodies at a considerable distance.

Nearly all this class of phenomena were discovered by Ampère and by Faraday, and were called by the latter "current-induction." According to his view the dielectric medium round a conducting circuit is strained, and subject to stresses, just as is the same medium round an electrically charged body. The one is called an electrostatic strain, the other an electromagnetic or electro-kinetic strain.

But whereas electrostatic phenomena occur *solely* in the medium—conductors being mere breaks in it, interrupters of its continuity, at whose surface charge effects occur but whose substance is completely screened from disturbance—that is not the case with electro-kinetic phenomena. It would be just as erroneous to conceive electro-kinetic phenomena as occurring solely in the insulating medium as it would be to think of them as occurring solely in the conducting wires. The fact is, they occur in both—not only at the surface of the wires like electrostatic effects, but all through their substance. This is proved by the fact that conductivity increases in simple proportion with sectional area; it is also proved by every part of a conductor getting hot; and it is further proved in the case of liquids by their decomposition.

But the equally manifest facts of current attraction and current induction prove that the effect of the current is felt throughout the surrounding medium as well, and that its intensity depends on the nature of that medium: we are thus wholly prevented from ascribing the phenomenon of self-induction or extra current to simple and straightforward inertia of electricity in a wire like that of water in a pipe.

We are thus brought face to face with another suggestion to account for these effects, viz., this: Since the molecules of a dielectric are inseparably connected with electricity, and move with it, it is possible that electricity itself has no inertia at all, but that the inertia of the atoms of the displaced dielectric confer upon it the appearance of inertia. Certainly they do sometimes confer upon it this appearance, as we see in the oscillatory discharge of a Leyden jar. For a displaced thing to overshoot its mean position and to oscillate till it has expended all its energy, is a proceeding eminently characteristic of inertia; and so, perhaps, the phenomena of self-induction are similarly, though not so simply, explicable.

Further consideration of this difficult part of the subject is, however, best postponed to Part III.

Energy of the Current.

I have now called attention to the fact that the whole region surrounding a circuit is a field of force in which many of the most important properties of the current (the magnetic, to wit) manifest themselves. But directly we begin thus to attend to the whole space, and not only to the wires and battery, a very curious question arises. Are we to regard the current in a conductor as propelled by some sort of end-thrust, like water or air driven through a pipe by a piston or a fan, or are we to think of it as propelled by side forces, a sort of lateral drag, like water driven along a trough by a blast of air or by the vanes of paddle-wheels dipping into it? Or, again, referring to the cord models, figs. 5, 6, and 13, were we right in picturing the driving force of the battery as located and applied where shown in the diagrams, or ought we to have schemed some method for communicating the power of the battery by means of belts or other mechanism to a great number of points of the circuit?

Prof. Poynting has shown that, on the principles developed by Maxwell, the latter of these alternatives, though apparently the more complicated, is the true one; and he has calculated the actual paths by which the energy is transmitted from the battery to the various points of a circuit, for certain cases.

We must learn, then, to distinguish between the flow of *electricity* and the flow of electric *energy*: they do not occur along the same paths. Hydraulic analogies, at least hydraulic analogies of a simple kind, break down here. When hydraulic power or steam power is conveyed along pipes, the fluid and its energy travel together. Work is done at one end of the tube in forcing in more water, and this is propagated along the tube and reappears at the distant end as the work of the piston. But in electricity it is not so. Electric energy is not to be regarded as pumped in at one end of a conducting wire, and as exuding in equal quantities

at the other. The *electricity* does indeed travel thus—whatever the travel of electricity may ultimately be found to mean—but the energy does not. The battery emits its energy, not to the wire direct, but to the surrounding medium; this is disturbed and strained, and propagates the strain on from point to point till it reaches the wire and is dissipated. This, Prof. Poynting would say, is the function of the wire: it is to dissipate the energy crowding into it from the medium, which else would take up a static state of strain and cease to transmit any more. It is by the continuous dissipation of the medium's energy into heat that continuous propagation is rendered possible.

The energy of a dynamo does not therefore travel to a distant motor through the wires, but through the air. The energy of an Atlantic cable battery does not travel to America through the wire strands, but through the insulating sheath. This is a singular and apparently paradoxical view, yet it appears to be well founded.

Think of a tram car drawn by an underground rope, like those in the streets of Chicago or Hampstead Hill. A contact piece of iron protrudes from the bottom of the car and grips the moving rope, which is thus enabled to propel the car. How does the energy of the distant stationary engine reach the car? *Vid* the rope and the iron connector, undoubtedly. They both have to be strong, and are liable to be broken by the transmitted stress.

Next, think of an electric tram car driven by means of a current taken up from an underground conductor, like that of Mr. Holroyd Smith at Manchester, or at the late Inventions Exhibition. A contact piece of wire rope protrudes from the bottom of the car and drags a little truck along the conductor, which is thus enabled to supply electricity to the electro-magnetic motor geared to the wheels. How does the energy of the distant dynamo reach the car in this case? *Not vid* the wire connector; not even *vid* the underground conductor. It travels from the distant dynamo through the general insulating medium between cable and earth, some little enters the conductor and is dissipated, but the great bulk flows on and converges upon the motor in the car, which is thus propelled. All the energy of the conducting wire is dissipated and lost as heat: it is the energy of the insulating medium which is really transmitted and utilised.

Phenomena peculiar to a Starting, or Stopping, or Varying Current.

There is a remarkable fact concerning electric currents of varying strength, which has been lately brought into prominence by the experimental skill of Prof. Hughes, viz., that a current does not start or stop equally and simultaneously at all points in the section of a conductor, but starts at the outside first. The fact is naturally more noticeable with thick wires than with thin, and it is especially marked in *iron* wires, for reasons which in Part III. will become apparent; but the general cause of it in ordinary copper wires can very easily be perceived in the light of the views of Prof. Poynting just mentioned.

For, remember that a current in a wire is not pushed along by a force applied at its end, so as to be driven over obstacles by its own momentum combined with a *vis a tergo*; but it is urged along at every point of its course by a force just sufficient to make it overcome the resistance there, and no more, the force being applied to it through the medium of the dielectric in which the wire is immersed. A lateral force it is which propels the electricity; and it naturally acts first on the outer layers of the wire or rod, only acting on the interior portions through the medium of the outside.

To illustrate this matter further, rotate a common tumbler of liquid steadily for some time and watch the liquid; dusting powder perhaps over it to make it more visible. You will see first the outer layer begin to participate in the motion, and then the next, and then the next, and so on, until at length the whole is in rotation. Stop the tumbler, and the liquid also begins gradually to stop by a converse process.

If the liquid sticks together pretty well, like treacle, the motion spreads very rapidly: this corresponds to a poor conductor. If the liquid be very mobile, the propagation of motion inward is slow: this corresponds to a very good conductor. If the liquid were perfectly non-viscous, it would correspond to a perfect conductor, and no motion would ever be communicated to it deeper than its extreme outer skin.

Think now of a long endless tube full of water, say the hollow circumference of a wheel, and spin it: the liquid is soon set in rotation, especially if the tube be narrow or the liquid viscous; but it is set in motion by a lateral not an end force, and its outer layers start first.

Just so is it with a current starting in a metal wire. If the wire be fine, or its substance badly conducting, it all starts nearly together; but if it be made pretty thick, and of well conducting substance, its outer layers may start appreciably sooner than the interior. And if it were infinitely conducting, no more than the outer skin would ever start at all.

In actual practice the time taken for all the electricity in an ordinary wire to get into motion is excessively short—something like the thousandth of a second—so that the only way to notice the effect is to start and reverse the current many times in succession.

If the hollow-rimmed wheel above spoken of were made to oscillate rapidly, it is easy to see that only the outer layers of water in it would be moved to and fro; the innermost water would remain stationary; and accordingly it would appear as if the tube contained much less water than it really does. The virtual bore of the pipe would, in fact, for many purposes be diminished. So is it also with electricity; the sectional area of a wire to a rapidly alternating current is virtually lessened so far as its conducting power is concerned; and accordingly its apparent resistance is slightly higher for alternating than for steady currents. The effect is, however, too small to notice in practice except with thick wires and very rapid alternations.

By splitting up the conductor into a bundle of insulated wires, thus affording the dielectric access to a considerable surface of conductor, the force is applied much more thoroughly, and so the effect spoken of is greatly lessened. The same thing is achieved by rolling out the conducting rod into a flat thin bar. Making the conductor hollow instead of solid offers no particular advantage, because no energy travels *via* the hollow space, it still arrives only from the outside; *unless*, indeed, the return part of the circuit is taken along the axis of the hollow like a telegraph cable. In this last arrangement all the energy travels *via* the dielectric between the two conductors, and none travels outside at all. It will be perceived therefore that, as in static electricity, the term "outside" must be used with circumspection: it really means that side of a conductor which faces the opposite conductor across a certain thickness of dielectric.

We learn from all this that, whereas in the case of steady currents the sectional area and material of a conductor are all that need be attended to, the case is different when one has to deal with rapidly alternating currents, such as occur in a telephone, or, again, such as are apt to occur in a Leyden jar discharge (see Part I, p. 431), or in lightning.

In all these cases it is well to make the conductor expose considerable surface to the propelling medium—the dielectric—else will great portions of it be useless.

Hence, a lightning conductor should not be a round rod, but a flat strip, or a strand of wires, with the strands as well separated as convenient: and though I have not yet mentioned the special effect of iron, I may as well say here that iron is about 90,000 times worse than copper for the purpose of a lightning conductor in respect of the phenomenon just described, seven times as bad on account of its inferior conducting power, and about twice as good as copper because of its higher melting point and specific heat.

The Question of Electrical Momentum again.

We are now able to return to the important question whether an electric current has any momentum or not, as it would have if it were a flow of material liquid. Referring to Part I. (p. 431), a hint will be found that the laws of flow of a current in conductors—the shape of the stream-lines, in fact—are such as indicate no inertia, or else no friction. Now Ohm's law shows that at any rate *friction* is not absent from a current flowing through a metal; hence it would appear at first sight as if *inertia* must be absent.

The stream-lines bear upon the question in the following kind of way. If an obstacle is interposed in the path of a current of water, the motion of the water is unsymmetrical before and behind the obstacle. The stream-lines spread out as the water reaches the obstacle, and then curl round it, leaving a space full of eddies in its wake (fig. 14).

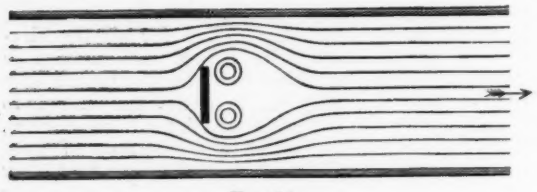


FIG. 14.

Stream-lines of water flowing through a pipe with an obstruction in it.

But if one puts an obstacle in the path of an electric current—say by cutting a slit in a conducting strip of tinfoil—the stream-lines on either side of it are quite symmetrical, thus—

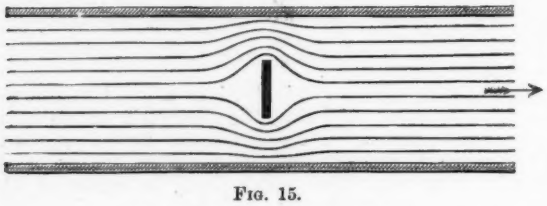


FIG. 15.

Electrical stream-lines past an obstacle.

And this is exactly what would be true for water also, if only it were devoid either of friction or of inertia, or of both.

Is not this fact conclusive, then? Does it not prove the absence of momentum in electricity?

Plainly the answer must depend on whether there is any other possible mode of accounting for this kind of flow. And there is.

For suppose that water, instead of being urged by something not located at or near the obstacle—instead of being left to its own impetus to curl round or shoot past as it pleases—suppose it were propelled by a force acting at every point of its journey, a force just able to drive it at any point against the friction existing at that point and no more; then the flow of water would take place according to the electrical stream-lines shown in fig. 15.

An illustration of such a case is ready to hand. Take a spade-shaped piece of copper wire or sheet, heat it a little, and fix it in quiescent smoky air; looking along it through a magnifier in a strong light you will see the warmed air streaming past the metal according to the stream-lines of fig. 15; and this just because the moving force has its location at the metal surface, and not in some region below it. (See Lord Rayleigh, *Nature*, vol. xxviii. p. 139). One cannot indeed say that it is propelled at every point of its course, but it is propelled at the critical points where the special friction occurs, and this comes to sufficiently the same thing.

We learn, therefore, that stream-lines like fig. 15 prove one of three things, not one of two; and the three things are: (1) that the fluid has no friction; or (2) that it has no inertia; or (3) that it is propelled at every point of its course.

If any one of these is true of electricity, there is no need to assume either of the others in order to explain the actual manner of its flow. Now we have just seen that, according to Prof. Poynting's interpretation of Maxwell's theory, the third of the above is true—electricity is propelled at every point of its course; consequently, as said in Part I. (p. 431), the question of its inertia so far remains completely open.

Voltaic Battery.

Leaving this singular mode of regarding the subject for the present, to return to it perhaps after Part III., let us proceed to ask how it comes about that a common battery or a thermopile is able to produce a current.

If we allow ourselves to assume the existence of an unexplained chemical attraction between the atoms of different substances, an explanation of the action of an ordinary battery cell is easy. You have first the liquid containing, let us say, hydrogen and oxygen atoms, free or potentially free—that is, either actually dissociated or so frequently interchanging at random from molecule to molecule that the direction of their motion may be guided by a feeble directive force. Each of these atoms in the free state possesses a charge of electricity—the hydrogen all a certain amount of positive electricity, the oxygen twice that amount of negative. Into this liquid you then plunge a couple of metals which attract these atoms differently: for instance, zinc and copper, which both attract oxygen, but zinc more than copper; or, better, zinc and platinum, the latter of which hardly attracts it at all; or, better still, zinc and peroxide of lead, one of which attracts oxygen, the other hydrogen.

Immediately, the free oxygen atoms begin moving up to the zinc, the free hydrogen atoms to the other plate.

When one speaks of the plates attracting the atoms, it is not necessary to think of their exerting a force on all those in the liquid, distant and near: all that is necessary is to assume a force acting on those which come within what is called "molecular range" of its surface—a distance extremely minute, and believed to be about the ten-millionth part of a millimetre. If the zinc plate removes and combines with all the oxygen atoms which come within this range, they will be speedily replaced by others from the next more distant layer by diffusion, and these again by others, and so on. And thus there will be a gradual procession of oxygen atoms all through the liquid towards the zinc, the rate of the procession being regulated by the force acting, and by the rate of diffusion possible in the particular liquid used. All the atoms which reach the zinc neutralise a certain portion of its electricity by means of the positive charge they carry, and thus very soon it would become positively electrified enough to neutralise its attractive power on the similarly charged oxygen atoms, and everything would stop. But if a channel for the escape of its electricity be provided by leading a wire from it to the copper plate, the circuit is completed, the electricity streams back by the wire, and the procession goes steadily on. The electricity thus imparted to the copper, or platinum, neutralises any repulsion it exerted on the negatively charged hydrogen atoms, and makes them in a similar way begin a procession towards it, deliver up their charges to it, combine with each other, and escape as gas.

Without going into all the niceties possible, this mode of thinking of the matter at least calls attention to some of the more salient features of a battery.

If, instead of two different plates, plates of the *same* metal be immersed, they will need to be oppositely electrified by some means before they are able to cause the two opposite processions, and so maintain a current in the liquid. This plainly corresponds to a voltameter.

Taking advantage of the known fact that the atoms are charged, Helmholtz avoids the necessity for postulating any chemical (non-electrical) force between zinc and oxygen, by imagining that all substances have a specific attraction for electricity itself, and that zinc exceeds copper and the other common metals in this respect.

He would thus think of the zinc attracting, not the oxygen itself, but its electric charge; and so would liken a battery cell still more completely to a voltameter. The polarisation or opposition force acting at the hydrogen-evolving plate he would account for by the attraction of hydrogen for negative electricity, and the consequent repugnance of the hydrogen atoms to part with their charges.

Thermo-electric Pile.

A thermopile may be thought of in the following way, but in trying to understand the nature of these actions at present one must admit that some speculation and vagueness exist.

We have seen that when electricity is propelled through or among the molecules of a metal it experiences a certain resistance or opposition force which is exactly proportional to the speed of its motion. In other words, there is a connection between matter and electricity in many respects analogous to fluid friction but varying accurately as the first power of the relative velocity. Hence, if an atom of matter be vibrating about a fixed point, it will tend to drive electricity to and fro with it; but if it be only one of a multitude, all quivering in different phases, they will none of them achieve any propulsion. This may be considered the state of an ordinary warm solid. But if from any cause a set of atoms could be made to move faster in one direction than in the reverse direction—to move forwards quickly and backwards slowly—then such an unsymmetrically moving set *will* exert a propulsive tendency and tend to drive a current of electricity forwards, simply because the force exerted is proportional to the velocity, and so is greater on the forward journey than on the return.

Wherever conduction of heat is going on along a substance the atoms are in this condition. They are driven forward infinitesimally quicker, by the more rapidly moving atoms at the hot end, than they are driven back by the less rapidly moving atoms in front. And hence such a slope of temperature exerts a propulsive tendency: there is an electromotive force in a substance unequally heated.

This fact was discovered theoretically and verified experimentally by Sir William Thomson.

But not only is there such a force at a junction of a hot and cold substance, there is also a force at the junction of two substances of different kinds, even though the temperature be uniform. It is not quite so easy to explain how it now comes about that the atoms at this kind of junction are moving faster one way than the other; nevertheless, such a thing is not unlikely, considering the state of constraint and accommodation which must necessarily exist at the boundary surface of two different media. However it be caused, there is certainly an E.M.F. at such a junction.

Thus, then, in a simple circuit of two metals, with their junctions at different temperatures, there are altogether four electromotive forces—one in each metal, from hot to cold or *vice versâ*, and one at each junction; and the current which flows round such a circuit is propelled by the resultant of these four.

But the contact force at a junction is by no means confined to metals. It occurs between insulators also, and it is to it that the striking effects produced by all frictional electric machines are due.

By thus noticing that the connection between matter and electricity, known as resistance and defined by Ohm's law, is competent to produce contact electromotive forces, we may perceive how it comes to pass that in good conductors such forces are so weak, while in insulators they are so strong. Electricity slips through the fingers of a metal as it were, and the driving force it can exert is very feeble; while an insulator gets a good grip and thrusts it along with violence.

The metals differ in their gripping power, and, roughly speaking, the best conductor makes the worst thermo-electric substance. A bad conductor, like antimony, or, still better, galena, or selenium, or tellurium, makes a far more effective thermo-electric element than a well-conducting metal. Not that specific resistance is all that has to be considered in the matter; there is also a specific relation between each metal and the two kinds of electricity. Thus, iron is a metal whose atoms have a better grip of positive than of negative electricity, and so a positive current gets propelled in iron from hot to cold. Copper, on the other hand, acts similarly on negative electricity, and it is a negative current which is driven from hot to cold in copper. And all the metals can be classed with one or other of these two, except, perhaps, lead, which appears to grip both equally, and so to exert no differential effect upon either.

Passage of Electricity through a Gas.

There remains to be said something about the way in which electricity can be conveyed by *gases*.

The first thing to notice is that there is no true conduction through either gases or vapours; in other words, a substance in this condition seems to behave as a perfect insulator—perhaps the only perfect insulator there is. Not even mercury vapour is found to conduct in the least. This shows that mere bombardment of molecules, such as is known to go on in gases, is not sufficient either to remove or to impart any electric charge.

The commonest way in which electricity makes its way through a gas, setting aside the mere mechanical conveyance by solid carrier, is that of disruptive discharge. Let us try and look into the manner of this a little more closely, if possible.

First of all, since locomotion is possible to the molecules of a gas the same as of any other fluid, it is natural to ask why electrolysis does not go on as in a liquid. Now, for electrolysis in a liquid two conditions seemed necessary: first, that the atoms or radicles in a molecule should be oppositely charged with electricity; second, that they should be in such a condition (whether by dissociation or otherwise) that interchanges of atoms from molecule to molecule, or, in some other way, a procession of atoms, could be directed in a given direction by a very feeble or infinitesimal force.

Since a gas does *not* act as an electrolyte, one of these conditions, or perhaps both, must fail. Either the atoms of a gas molecule are not charged, which is a plausible hypothesis for elementary gases, or else the atoms belonging to a gas molecule remain individually belonging to it, and are not readily passed on from one to another.

When one says that a gas does not act as a common electrolyte, the experimental grounds of the statement are that a finite electrostatic stress certainly is possible in its interior—a stress of very considerable amount; and when this stress does overstep the mark and cause the electrode to yield, the yielding is evidently not a quiet and steady glide or procession, but a violent breaking down and collapse, due to insufficient tenacity of something. One may therefore picture the molecules of a gas, between two opposite electrodes or discharge terminals maintained at some great difference of potential, as arranged in a set of parallel chains from one to the other, and strained nearly up to the verge of being torn asunder. In making this picture one need not suppose any fixture of individual molecules: there may be a wind blowing between the plates; but all molecules as they came into the field must experience the stress, and be relieved as they pass out.

If the applied slope of potential overstep a certain limit, fixed by observation at something like 33,000 volts per linear centimetre for common air, the molecules give way, the atoms with their charges rush across to the plates, and discharge has occurred. The number of atoms thus torn free and made able to convey a charge by locomotion is so great that there has never been found any difficulty in conveying any amount of electricity by their means. In other words, *during* discharge the gas becomes a conductor, and, being a conductor by reason of locomotion of atoms, it may be called an electrolytic conductor.

But whether the charge then possessed by each carrier atom intrinsically belonged to it all the time, or whether it was conferred upon the components of the

molecules during the strain and the disruption, is a point not yet decided.

What is called "the dielectric strength" of a gas—that is, the strain it can bear without suffering disruption and becoming for the instant a conductor—depends partly on the nature of the gas, and very largely on its pressure. Roughly, one may say that a gas at high pressure is very strong, a gas at low pressure very weak. An ordinary electrolyte might be called a dielectric of zero strength.

One reason why pressure affects the dielectric tenacity of a gas readily occurs to one: it is certainly not the only one, but it can hardly help being at least partially a *vera causa;* and that is, the fact that in a rare gas there are fewer molecules between the plates to share the strain between them.

Thus if 40,000 volts per centimetre break down ordinary air, 40 volts per centimetre ought to be enough to effect discharge through air at a pressure of about $\frac{3}{4}$ millimetre of mercury; and at a pressure of 50 atmospheres 2,000,000 volts per centimetre should be needed.*

A Current regarded as a Moving Charge.

To review the ground we have covered so far. We first tried to get some conception of the nature of electrostatic charge, and the function of a dielectric medium in static electricity. We next proceeded to see how far the phenomena of current electricity could be explained by reference to electrostatics. For a current, being merely electricity in locomotion, need consist of nothing but a charged body borne rapidly along.

Charge a sphere with either positive or negative electricity, and throw it in some direction: this constitutes a positive or a negative current in that direction. There is nothing necessarily more occult than that. And a continuous current between two bodies may be kept up by having a lot of pith balls, or dust particles, oscillating from one to the other, and so carrying positive electricity one way, and negative the other way. But such carriers, as they pass each other with their opposite charges, would be very apt to cling together and combine. They might be torn asunder again electrically, or they might be knocked asunder by collision with others. Unless they were one or other, the current would shortly have to cease, and nothing but a polarised medium would result.

Instead of pith balls, picture charged atoms as so acting, and we have a rough image of what is going on in an electrolyte on the one hand, and a dielectric on the other. The behaviour of metals and solid conductors is more obscure. Locomotive carriage is not to be thought of in them; but, inasmuch as no new phenomenon appears in their case, it is natural to try and picture the process as one not wholly dissimilar; and this is what in one place we tried to do; with, however, but poor success.

I have said that an electric current need be nothing more occult than is a charged sphere moving rapidly; and a good deal has been made out concerning currents by minutely discussing all that happens in such a case. But, even so, the problem is far from being a simple one. One has to consider not only the obviously moving charge, but also the opposite induced charge tied to it by lines of force (or tubes of induction, as they are sometimes called), and we have this whole complicated system in motion. And the effect of this motion is to set up a new phenomenon in the medium altogether—a spinning kind of motion that would not naturally have been expected; whereby two similarly charged spheres in motion repel one another less than when stationary, and may even begin to attract, if moving fast enough; whereby also a relation arises between electricity and magnetism, and the moving charged body deflects a compass needle. Of which more in the next Part.

(To be continued.)

* It is true that tension per unit area, or energy per unit volume, is proportional to the *square* of the potential slope, and I attach no special importance to the simple proportion assumed in the text. There is a great deal more to be said on these subjects, but this is scarcely the proper place to say it.

CONNECTION OF SEVERAL DYNAMO MACHINES IN ONE AND THE SAME EXTERIOR CIRCUIT.

IN the practice of electric lighting there exists a problem the importance of which is well known to all engaged in this branch of industry. When we supply an exterior circuit in which there is a variable number of lamps we have almost always several machines which are intercalated according to the needs of the service, and the difficulty lies in the successive introduction of these machines without affecting the luminous intensity of the lamps which are in action at the moment.

The solution of this problem, says M. P. H. Ledeboer, in *La Lumiere Electrique*, naturally varies with the system adopted, but the only one which occurs at present in ordinary practice is that where the electromotive force between the two principal conductors ought to remain constant, and where the machines which are coiled in derivation or in a compound manner are also in derivation with reference to the principal circuit. We believe that almost all engineers engaged in this kind of service have their own special methods for avoiding the variations of the lighting, but we have not hitherto met with a systematic explanation of this question.

Hence we borrow from a special work on installations for electric lighting very complete instructions. We shall subsequently return to this subject for the sake of making known our own views.

The following is the extract in question:—

Connection of Machines in Quantity or in Parallel Arc.

In large lighting establishments, especially in central stations, several machines are connected in parallel arc with a simple conductive system.

They can be associated in this style only when the machines are coiled in an analogous manner.

As far as possible one and the same transmission ought to be used; if each dynamo has its special motor care must be taken that all the machines move with the same speed.

a. Machines in derivation arranged in quantity.

Fig. 1 shows this arrangement.

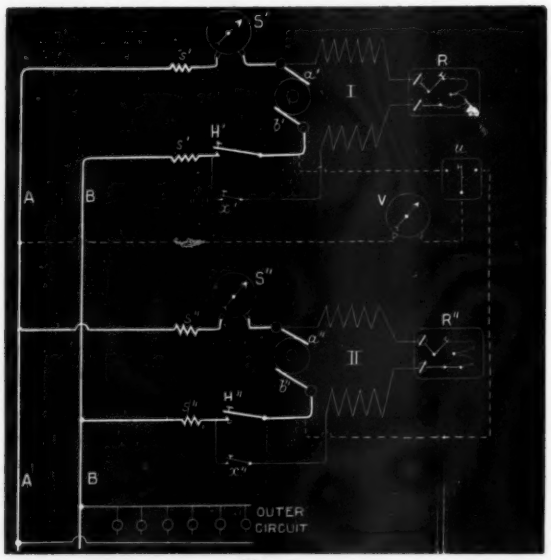


FIG. 1.

The brushes of the same name, *a*, are connected directly with the conductor, A; the opposed brushes, *b*, are connected to this conductor by the intermediance of the interruptors, H. The wire of the inductors is attached directly, on the one hand, to the brushes, *a*, and on the other to the principal conductor beyond the interruptor, H. To interrupt the current in the inductors we make use of the interrupters, *x*, arranged at the side of the interruptors, H; it is convenient to attach both to the same machine. The regulators of

the current, R, for the different machines should be fitted side by side; it is convenient to arrange these regulators in such a manner that the current may never be interrupted. The main conductors, or at least one for each machine, are fitted with a safety interrupter corresponding to the normal intensity of the currents circulating in the dynamos.

For each machine there is required an ampèremeter to measure the intensity of the current produced. But, on the other hand, we use for all the machines only a single voltmeter, V.

This voltmeter is attached directly by one of the extremities to the conductor, A, which is common to all the machines, the other end is joined to the commutator, *u*, and by its means to the brushes, *b*; these arrangements enable the voltmeter to be applied to each machine as it may be needed.

We suppose that there is no notable loss of tension between the conductor, A, and the machines. In the contrary case, the extremity of the voltmeter must be applied directly to the brushes, *a*, and to this end a bipolar commutator must be applied at *u*.

We may, at the outset, have to set in motion all the machines at once, or some after the others. The former case is the simpler and is met with especially in small installations where, *e.g.*, two machines are in use. Then, before starting the machines, we close the interruptors, *x* and H. When the machines have acquired their normal speed we diminish uniformly the resistance of the regulators, R, until the electromotive force becomes normal. The current must be distributed uniformly among all the dynamos. If, *e.g.*, the ampèremeter of one machine shows too great intensity, we insert resistance on the regulator dependent on this machine, until the intensity becomes equal to that of the other dynamos. It is sometimes necessary to set the machines in motion before introducing the circuit; on inserting the latter, the interruptor, *x*, must always be closed before closing the interruptor, H. Having thus operated on all the machines, we remove equal resistances from each of the regulators, R. When at the outset we wish to start only one machine, for instance, No. I., we proceed as above, leaving the others out of circuit.

When the consumption of light augments, which we recognise by the ampèremeter, S, we introduce the other machine, No. II. To this end we close the interruptor, *x'*, and try, by means of the voltmeter, if it gives a current. When it is thus, we place the crank of the regulator, R', approximately in the position which it must occupy in machines in motion and close the interruptor, H. We place then the crank of each current regulator so that the intensity may be equal in the two machines, so as to be able to regulate the electromotive force by acting uniformly upon the two regulators.

In order to introduce another machine we operate in the same manner; we regard the totality of the regulators of the machines already in circuit as if they formed a common generator.

For ceasing work we may stop all the machines simultaneously and then put them out of circuit, or stop each machine one after the other. In the latter case we begin by opening the interruptor, H, we open then the interruptor, *x*, and can then stop the machine.

In large installations we make use of groups of lamps; the introduction into circuit becomes then rather more complicated; but in compensation the working is more certain when we insert fresh machines.

We have a certain number of groups of lamps mounted in the machine room. These lamps form groups furnished with interruptors; they serve to place each machine, before its introduction into the main circuit, exactly in the same conditions as the machines already in action.

One of the poles of this assemblage of lamps (fig. 2) communicates with the conductor, A, attached directly to all the machines. The other pole has a separate conductor, E, and is connected by the interruptors to the various machines.

Some details on the other appliances are here necessary. There are to each machine two interruptors, *y* and *x*, connected to the wires of the inductors; one of them, *y*, is connected directly with the machine; the other, *x*, is in derivation on the main conductor, B. This second interruptor is necessary to prevent the reversal of the poles of the machine; if we wish to place a fresh machine in circuit we pass into the inductors the current produced by the other machines. The regulators, R, must be placed side by side. They are generally arranged so that the cranks of all these apparatus communicate with a common pulley, which

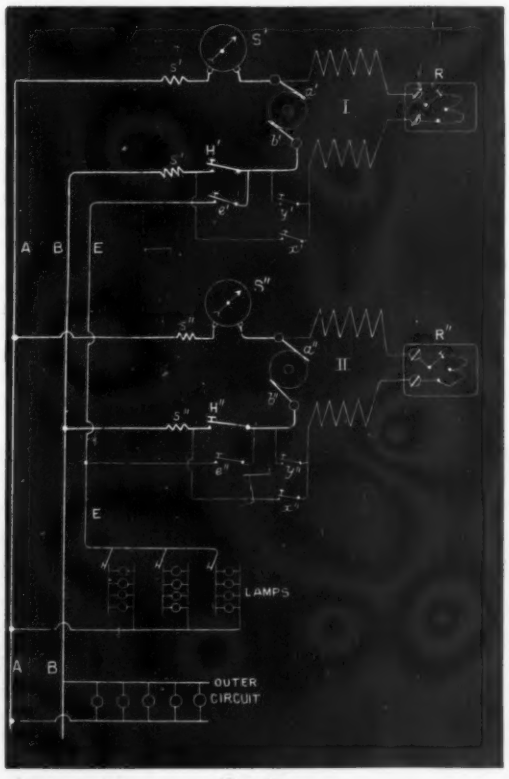


FIG. 2.

enables these cranks to be turned separately or together, as it may be desired. The use of a bipolar commutator is the best means of connecting the voltmeter to the various machines; in large installations there is often a second voltmeter connected directly to the two main conductors, A and B. The other apparatus is arranged as already described.

Generally, when beginning to work the machines are introduced into circuit in succession. If, for instance, we have to begin by introducing into circuit the machine No. I. (fig. 2), it is set in motion according to the foregoing indications. To introduce machine II. into circuit we close the interruptor, *x*, as soon as the normal speed has been reached. We measure the electromotive force of machine I., and then connect the same voltmeter with the machine II. We then close the break circuit, *e''*, and insert gradually groups of lamps until machine II. does the same work as machine I., controlling the tension by means of the regulator, R''. After this we close the interruptor, H'', and throw the group of lamps out of circuit, governing the electromotive force by means of the regulator, R, and then open the interruptor, *e'*. When finishing we close the interruptor, *y''*, and then open the interruptor, *x''*.

To put a machine out of circuit we likewise make use of the groups of lamps, which enables us to effect the transition gradually and to avoid oscillations in the lighting. We close the interruptor, *e''*, of the machine to be thrown out of circuit, *e.g.*, II. (fig. 2), and introduce the lamps group by group so that the intensity of the current in II. becomes equal to that which will be afterwards the intensity in the other machines. At the same time we regulate simultaneously the electromotive force in all the machines. After having then

opened the interruptor, H, we throw out of circuit by degrees, the groups of lamps and stop the machine II.

To place a machine out of circuit without making use of the groups of lamps, we open first the interruptor H, and then the interruptor *y*, as already explained.

b. Machines with double wrapping, connected in quantity.

The brushes of similar name of all the machines (fig. 3) must communicate together. When the machines are in circuit the brushes, *a*, communicate directly among themselves by the medium of the principal conductor, A. The brushes, *c*, are connected among themselves by a conductor, C, which must be established separately, this wire should be 3 or 4 millimetres in diameter. When the machines are in circuit their extremities, *b*, are connected by the common conductor, B. Each machine is fitted with an ampèremeter, S, which is placed in circuit at the main conductor setting out from the brush, *a*; it is also provided with a bipolar interruptor, H. This last instrument enables us to throw simultaneously into and out of circuit the two main conductors issuing from the machine. Independently of the interruptors, H, interruptors, *x*, must also be installed for the wrapping in derivation. This is connected on the one hand directly to the brushes, *c*, and on the other, beyond the interruptors, H, it joins the main conductor setting out from the brushes, *a*. The regulators which must be installed side by side must be arranged in such a manner as not to interrupt the current.

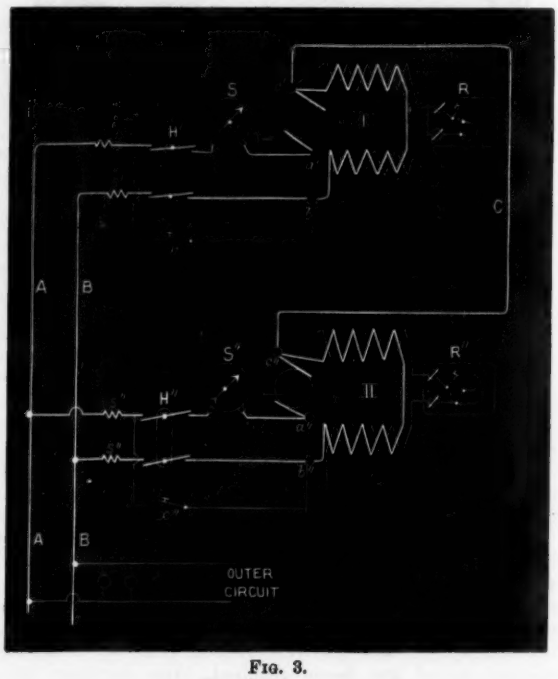


FIG. 3.

As already mentioned, all the main conductors issuing from the dynamos should be provided with safety wires, *s*. The voltmeter is furnished with a bipolar commutator, and can thus, as it may be needed, be attached to the extremities of different machines.

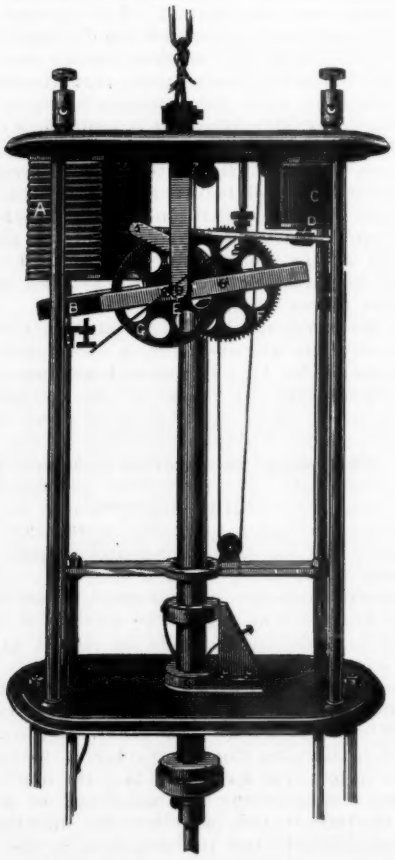
To set the machines in motion we proceed according to rules analogous to those given above. If we wish that all should act simultaneously from the very beginning we close the interruptors, *x* and H; we insert all the resistances in the regulators, R, and set in motion. As soon as the normal number of rotations is reached we seek to attain the desired electromotive force by acting uniformly upon all the regulators, R; if the machines have not all the same intensity of current we turn the cranks of the regulators separately. It is sometimes needful to start the machines before closing the interruptors (*x* first and then H). To put into circuit a machine (*e.g.* II.) when there are already others at work, we close the interruptor, x'', when the normal number of rotations is reached and place the crank of the regulator, R, approximately in the same position as the cranks of the regulators of the machines in motion. Care must be taken to test by means of the voltmeter, if the machine gives a current. If so, the interruptor is closed. To extinguish the lights all the machines may be simultaneously stopped without previously opening the interruptors, or the machines may be thrown out of circuit in succession, opening first H and then *x*.

THE "LUTHER" ARC LAMP.

NOTWITHSTANDING the number and variety of arc lamps brought before the public during the last few years, it must be admitted that perfectly steady and reliable regulators are rare.

Many inventors have produced extremely simple methods of regulation, which, however, have been obtained at the expense of the steadiness of the light, the feed of the carbons being coarse and irregular, as is generally the case with all lamps depending upon a "clutch," or similar device to alternately grip and release the carbon holder.

On the other hand, there are several clockwork lamps, giving a steady light, but on account of their complicated mechanism are not reliable and soon get out of order, which renders them unsuitable to be placed in the care of unskilled persons, or to be used in exposed or dusty situations.



The "Luther" lamp has been designed by Mr. Luther Hanson to obviate these defects, the mechanism being at once simple, and at the same time a remarkably fine feed of the carbon is obtained, which averages $\frac{1}{600}$th of an inch, so that it may be considered as practically continuous.

The accompanying illustration represents the lamp ready for switching on the current. A, the main coils or lifting magnet for striking the arc. B, armature to main coils, attached to one end of a rocking frame which is pivotted at E. C, shunt coils of fine wire, connected across the arc. D, shunt armature, which is kept in position by a small spring. F, a toothed wheel,

the arbor of which also carries a drum around which the cord is passed; one end of the cord being fastened to the lamp frame and the other to the positive carbon holder or rod. It will be noticed that the cord first passes under a small pulley which is attached to the frame carrying the negative carbon, it then passes round the drum on the arbor of F, and over a small pulley attached to the under side of the lamp frame, down to the positive carbon or holder to which the end is secured. G is a brake wheel which by means of a small pinion at the back is geared into the toothed wheel, F.

The position of the lamp, as shown, is that the carbons are in contact, and that it is ready for action. On the passage of a current through the main coils, A, the armature, B, is attracted, and the rocking frame being lifted, the positive carbon is slightly raised and the arc is struck, the feed then progresses in a steady, continuous manner; at the same time the brake wheel, C, is raised until it touches the arm, D, of the shunt armature. Immediately upon the lengthening of the arc or the consumption of the carbons, there is more current sent through the shunt coils, which thus attracts the armature, D (overcoming the spring), and thereby releases the brake wheel, C, allowing the lamp to feed, the + carbon going down and the — negative coming up. It may be noticed that by means of the pulleys, the positive carbon holder moves through double the distance that the negative does, the result being that the lamp is self-focussing, the arc being maintained always in the same position.

Besides the self-focussing result, it is contended that the lamp has a fine regular feed, and in case of the arc being broken by accident or defects in the carbons, an instant feed is obtained, as the armature of the main lifting magnet is at once released, the carbons immediately coming together, re-establishing the arc. In many lamps should the arc be broken, the light is extinguished until the clockwork mechanism runs down, which takes some time; whereas in the present lamp the action is immediate. These lamps can be used in series or in parallel, and they are in use with dynamos of most of the well known makers, not being confined to their own dynamo for their satisfactory working.

The "Luther" arc lamp is being manufactured by Messrs. Hanson and Charles (the patentees), of Halifax, and it has been adopted with great satisfaction in numerous installations.

TELEPHONE INVESTIGATIONS.

By J. R. PADDOCK.

THE following investigations were suggested to my mind from observing the marked advantage gained in modern telephone transmitters by the use of granulated carbon. It occurred to me to try the effect of the same and other powders in the Reis instrument, particularly in the cubical box transmitter, as the latest commercial instrument has returned in many of the details of its construction to this form of a transmitter, viz., to a platinum diaphragm placed horizontally, with the other electrode suspended above it, and the intermediate space filled with granulated carbon. (See paper of Lockwood, American Institute of Electrical Engineers, May 19th, 1886.)

My first experiment was to place a quantity of granulated carbon (made by drilling out carbon battery plates) upon the platinum patch of the Reis instrument, and the result was in accordance with my expectation. It transmitted speech under these circumstances clearly and distinctly. I next reduced the quantity of carbon dust or grains on the diaphragm, and found the result quite as good as before. I then removed all but a few grains between the electrodes. Still the instrument operated as a good transmitter. After a little time, however, these grains of carbon were scattered and had to be renewed.

I then prepared granulated platinum by drilling out pieces of platinum foil, and placed this granulated platinum upon the platinum patch of the diaphragm. The result was a harsh, grating quality of sound. Tried black lead dust from lead pencil (A. W. Faber's No. 4) with much better results. The quality of the speech transmitted at once became smooth and at the same time more distinct. Recalling the experiments of Mr. Edison with lampblack, I prepared some soot deposited at low temperature from a smoking kerosene lamp, and placed a few grains of this upon the platinum patch. The results were very satisfactory, and the quality and loudness of the speech transmitted surpassed all previous results.

I next obtained finely divided platinum (known as platinum sponge) from H. M. Raynor, 25, Bond Street, New York. Also soft and well annealed platinum foil from Baker & Co., and dioxide of lead, iodide of copper, and a 10 per cent. solution of the bichloride of platinum, together with pure charcoal made from willow wood. The charcoal was heated to redness and plunged into the solution of bichloride of platinum and afterward pulverised, thus forming with the others a new series of metallic powders for trial.

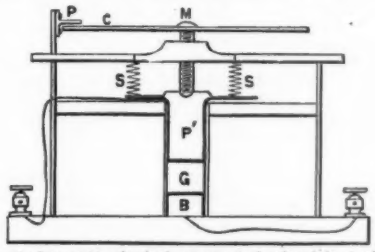
I first tried the platinum sponge, which gave results that were not satisfactory. The sounds were harsh and grating. I next tried the charcoal impregnated with platinum, which gave better results, the sounds becoming more agreeable to the ear. The iodide of copper was equally good, but soon disintegrated under the action of the current. The dioxide of lead was then tried, and found to surpass all the other powders of this series, giving admirable results. The articulate speech transmitted by means of it was clear, distinct, and loud—and its efficiency closely approximated to that of carbon or lampblack. I next tried the following mixtures of powders:—Platinum and lead, platinum and carbon, iron and carbon, each in equal parts. The results were not as satisfactory as when used alone. The addition of oil or sirups improved their action slightly.

Having noticed that the diaphragm when in vibration soon scattered the grains of powder, I made a cavity in the centre of the platinum patch and placed the powder within it; but the volume of sound from the receiver was reduced one-half thereby, and the deeper the point of the hammer electrode was immersed in the powder, the fainter the sounds became. Returning to a shallow indentation in the plantinum patch, the sounds became louder. This was owing to the fact that the sides of the cavity offered comparatively free passage for the electric current; and I therefore constructed rings of non-conducting material, which, when placed on the platinum patch, overcame that difficulty and at the same time kept the powder from being scattered. The results obtained thereafter were entirely satisfactory.

The next step was to ascertain if possible *what was the principal agent in the variation of resistance by means of these powders.* Whether it was the loose contacts of the grains of powder among themselves or the surface resistance of the powder upon the electrodes, or both combined. After many trials it was found that, when the upper electrode was fixed so as not to be capable of movement itself, no sound proceeded from the receiver, notwithstanding that the particles of powder surrounding it were in constant agitation, and the intimacy of their contacts among themselves continually changing, under the action of the voice; and again, the upper electrode being removed, a piece of platinum wire, suitably connected to the binding post, was held in the hand, with one end dipping into the powder. In this way, by varying the rigidity with which the platinum wire was held, the instrument could be made to transmit speech or not at pleasure; and it was found again *that the upper electrode required to be free to move up and down on the surface of the powder in order to obtain sounds in the receiver —which pointed to the surface contact of the upper electrode with the powder as the place where the principal variatiion of the electric current takes place,* and tended to show that all other variation was exceedingly small in comparison. Still it appeared reasonable that the violent agitation of all of these loose particles would aid somewhat in producing the final result.

CAUSE OF THE EFFICIENCY OF POWDERS IN TELEPHONE TRANSMITTERS.

In order to throw additional light upon the subject, *I have endeavoured to ascertain the range of variation in resistance due to surface contact and pressure when powders of this kind are introduced into an electric circuit,* and for this purpose constructed an apparatus consisting of a glass tube, one centimetre in diameter, to which was fitted a mixed metallic base and movable rod or plunger (brass). This rod was moved by means of a micrometer screw, with 32 threads to the inch, the head of the screw being divided into 360 degrees. It was suspended by spiral springs, against the tension of which the screw moved.



P, pointer, P', plunger, M, micrometer screw, C, circular plate, G, glass tube, S, spiral spring. B, base piece.

The minimum measurement of the screw was $\frac{1}{11520}$th of an inch, but the error of the apparatus was so great that measurements were taken with 10 degrees at a time, giving $\frac{1}{1152}$nd of an inch, compared with which the error would be perhaps one per cent. The whole was suitably fixed in a solid framework and the metallic base-piece and rod connected to binding posts, thus forming the electrodes of the circuit.

The space between these electrodes to the depth of one centimetre was filled with the powder to be examined. Each powder by this means formed a cylinder one centimetre in diameter and

one centimetre in length. These dimensions were chosen as furnishing a basis for the estimation of the resistance of a unit cube or the specific resistances of these substances, provided the measurements proved of sufficient value.

The micrometer screw was first turned down to what I may call the zero line for each experiment, which line was always taken just below the contact surface, so as to give each powder an equal compression of its mass and also to render its surface conformable to that of the electrodes. After this the screw was reversed and the upper electrode raised. The measurements of resistance were then taken by means of the *bridge method* and with a mirror galvanometer.

The following table gives the result for three of the most important powders:—Metallised carbon (from specimen of very fine French electric light carbons) peroxide of lead ($Pb. O_2$), peroxide of manganese ($Mn. O_2$), and also for a solid specimen of carbon taken from the same piece and of the same dimensions.

TABLE SHOWING VARIATION IN ELECTRICAL RESISTANCE FOR CONTACT SURFACE AND PRESSURE IN CYLINDER ONE CENTIMETER IN LENGTH AND DIAMETER.

Revolutions of screw, showing contact and pressure.	Carbon, solid.	Carbon, powdered.	Peroxide Lead, powdered.	Peroxide Manganese, powdered.
	Ohms.	Ohms.	Ohms.	Ohms.
First contact.	99,000	93,125	149,000	248,000
$\frac{1}{1152}$ inch.	24,000	74,000	60,000	19,548
$\frac{2}{1152}$ "	16	59,000	29,000	9,520
$\frac{3}{1152}$ "	1·3	31,857	14,050	6,246
$\frac{4}{1152}$ "		20,428	5,977	5,122
$\frac{5}{1152}$ "		14,000	1,435	4,035
$\frac{6}{1152}$ "		11,000	350	3,287
$\frac{7}{1152}$ "		9,000	220	2,795
$\frac{8}{1152}$ "		7,670	95	2,448
$\frac{9}{1152}$ "	0·21	6,317	21	2,160
$\frac{10}{1152}$ "		5,000	11·2	1,970
$\frac{11}{1152}$ "		3,965	8·3	1,776
$\frac{12}{1152}$ "		3,199	7·1	1,500
$\frac{13}{1152}$ "		2,703	6·5	1,382
$\frac{14}{1152}$ "		2,457	6·0	1,290
$\frac{15}{1152}$ "		1,590	5·6	1,206
$\frac{16}{1152}$ "		1,307	5·2	1,127
$\frac{17}{1152}$ "		900	5·0	1,054
$\frac{18}{1152}$ "		666	4·9	996
$\frac{19}{1152}$ "	0·11	332	4·8	948
$\frac{20}{1152}$ "		170	4·72	913
$\frac{21}{1152}$ "		105	4·65	878
$\frac{22}{1152}$ "		52	4·57	843
$\frac{23}{1152}$ "		6	4·48	808
$\frac{24}{1152}$ "	0·10	3·4	4·40	773
$\frac{50}{1152}$ "	0·067	0·638	2·15	502

By reference to this table it will be seen that the first contact that was measured gives 99,000 ohms for solid carbon, 93,125 ohms for powdered carbon, 149,000 ohms for peroxide of lead, and 248,000 ohms for peroxide of manganese. These figures, however, cannot be relied upon as accurate comparative measures, inasmuch as the certainty of making such light contacts is well nigh impossible. They represent, however, the relative resistances roughly, and by reference to the last figures in each column the range of variation in each is easily seen. In the case of carbon powdered, for instance, *a pressure of $\frac{50}{1152}$nds of an inch caused the resistance to fall to less than one ohm?* In peroxide of lead *to a little over two ohms!* While peroxide of manganese *was reduced no lower than 502 ohms!*

These results also show, as was anticipated, that by far the greater part of the variation in resistance is due to surface contact. *The first three turns of the screw, representing $\frac{3}{1152}$nds of an inch, reduced the resistance far more than the entire remaining pressure, which was nearly 16 times the first.* In the case of solid carbon the range of resistance is plainly seen to be limited very nearly to surface contact.

It is evident that the difference in range of resistance shown between carbon solid and carbon powdered is largely due to the degree of intimacy of contact of the grains of the powder produced by pressure, and not to surface contact with the electrodes.

This comparison also indicates, when looked at in connection with the motion of the screw, *that a powder furnishes a much wider range of vibration for the electrodes of a telephone transmitter, which is a decided advantage in most cases.*

Peroxide of lead furnishes a range of variation in resistance easily compared with that of carbon, and it will be seen at first sight that the fall of resistance was much more rapid, which may be due to the fact that the peroxide of lead is very easily compressed under light pressure. The comparison is most significant, as furnishing *the closest approximation to that of carbon, solid or powdered, of any substance experimented upon.* Doubtless this was the reason why peroxide of lead was found in my previous experiments to be such an excellent substitute for carbon in telephonic operations.

Peroxide of manganese was found to have a considerable range of variation, but altogether too high a specific resistance for use in telephone transmitters. Other oxides of the metals were tried with the same result, such as the peroxide of iron ($Fe_2 O_3$), which was too high for measurement.

HEAT EFFECTS IN TELEPHONE OPERATIONS.

Some years ago I accidentally discovered what was then new to myself, *that microphone transmitters would also act as receivers,* and subsequently that any loose contact in an electric circuit would reproduce sounds made at a telephone transmitter. That the heating effect of the current at the joint should have something to do with the reproduction of these sounds has always appeared probable, provided that the variations of heat were sufficiently rapid to coincide with those of the current. That such heat changes *are* sufficiently rapid in lampblack, for instance, to reproduce musical and articulate sounds, is demonstrated by the well-known experiments with a beam of intermitted radiant heat (Tyndall's exp.), and still more recently the *"thermal telephone"* has shown the same to be true for *a fine metallic wire heated by means of the electric current.* (Chas. R. Cross, 1885.)

In the case of a loose contact surface, therefore, we may consider whether this heat effect is the same or in an *opposite phase* to that of the varying strength of the current passing through the joint. In the case of metals, the temperature coefficient being positive, *resistance increases* with the strength of the current; but in the case of carbon, whose temperature coefficient is negative, *resistance decreases* with the strength of the current.

In order to ascertain how important a factor heat might become at a light contact surface, I undertook the following experiments:—

The powders whose resistances had been measured for contact and pressure were now measured for changes in temperature. In order to do this, the apparatus before described was immersed in a bath of water at the temperature of 25° Centigrade, and the screw having been brought down to a zero line chosen with reference to light contact, the resistance was measured for each substance by the bridge method as before.

TABLE SHOWING VARIATION IN ELECTRICAL RESISTANCE FOR TEMPERATURE.

In cylinder one centimetre in length and diameter.

Temperature in Centigrade Degrees.	Carbon Powdered.	Peroxide Lead Powdered.	Peroxide Manganese Powdered.
	Ohms.	Ohms.	Ohms.
25°	2,000	2,750	5,520
26°	1,912	2,409	5,200
27°	1,811	2,061	5,000
28°	1,609	1,803	4,707
29°	1,459	1,586	4,450
30°	1,375	1,375	4,229
31°	1,237	1,100	4,070
32°	1,143	726	4,017
33°	1,054	575	3,960
34°	1,000	485	3,900
35°	910	408	3,838
36°	863	304	3,785
37°	807	255	3,762
38°	732	225	3,731
39°	695	208	3,687
40°	657	200	3,644
41°	621	191	3,600
42°	578	184	3,573
43°	530	176	3,545
44°	470	167	3,519
45°	No change.	162	3,498
46°	No change.	158	3,485
47°	Sudden change.	150	3,473
48°	185	145	3,461
49°	152	140	3,449
50°	112	136	3,438
51°	71	133	3,431
52°	42	130	3,425
53°	21	127	3,418
54°	18	124	3,412
55°	15	121	3,406

The temperature of the bath was then raised one degree at a time, and the resistance measured for each degree of temperature from 25° to 55° Centigrade. Observations were taken at intervals of 10 to 15 minutes apart. The table above gives the results, and it will be observed that carbon (powdered) fell from a resistance of 2,000 *ohms* to 15 *ohms*, and peroxide of lead from 2,750 *ohms* to 121 *ohms* for 30° of temperature, that is, in being heated from 25° to 55° Centigrade. By reference to the first few degrees of temperature, the exceedingly rapid fall of resistance shows *how powerful a factor in variation of resistance heat may become in cases of light contact.*

It is also seen at a glance that both the oxides of lead and manganese have like carbon *negative heat coefficients.*

In order to ascertain the presence of *thermo-electric* currents, the battery was disconnected and the heat experiments were repeated, but such currents were very slight indeed, scarcely noticeable. The polarisation or "storage" effect, however, was greater, and in the case of peroxide of lead a return current was quite marked after each experiment.

These experiments are intended to form a basis for further investigation in the future. So far as carried they open an interesting field for study, and furnish suggestions for a better solution of the telephonic problem.

Stevens Institute of Technology, *July*, 1887.

PRIMARY BATTERIES FOR ILLUMINATING PURPOSES.

AT a meeting of the Society of Engineers, held at Westminster Town Hall on Monday evening, November 7th, Professor Henry Robinson (President) in the chair, a paper was read by Mr. Perry F. Nursey (Past President) on "Primary Batteries for Illuminating Purposes." The author commenced by observing that there was a wide field open for electric lighting by primary batteries in houses generally, owing to the costliness of the steam-driven dynamo-electric system. He then explained the principles of the primary battery, and outlined its history; after which he laid down the leading conditions which should obtain in a battery for electric lighting on a broad and general scale. He then described some primary batteries for special purposes and for general lighting; the latter included those of Holmes and Burke, Ross, Coad, Lalande, Skrivanow, Upward, Pollak, Newton, D'Humy, and Friedlaender, and the "Regent," the "Union," and the "Eclipse" batteries. The author having pointed out the leading characteristics, as generally described in newspapers, of the various batteries, observed that some of them had shown themselves to be efficient and useful by the results of their adoption in mansions and large establishments.—The paper concluded as follows:—

The author has now described sixteen primary batteries, being all that have come under his notice, and has given such particulars concerning them as the limitation he has prescribed for the subject will permit. It might be expected that he should now proceed to analyse the various systems, and to pronounce an opinion upon their relative merits. Two things stand in the way of this. In the first place, the present paper has been prepared at short notice, to meet an emergency, and was only commenced three weeks since, so that there has been neither time nor opportunity for such a careful examination to be made as should entitle the conclusions drawn from it to respect. In the next place, the author conceives that no single person should undertake the task of examination. Electric lighting is still but in its infancy, and no system ought to be either condemned or approved without very careful and exhaustive trial. To this end the various batteries should be placed unreservedly in the hands of three disinterested professional men—an electrician, a chemist, and an engineer, for all three professions are represented in every primary battery system. The author is not quite sure that the various patents should not undergo a preliminary investigation by a patent agent. We are, however, fortunate in having among us to-night several eminent electricians, and from these masters of the science, as well as from the inventors of the batteries, we may hope to hear something more respecting the practical value of these batteries than the author has been able to give in his paper. Broadly and generally speaking, it appears to him that it has yet to be proved that any one of the batteries could be applied to the partial illumination of moderate sized houses—for that is what is really wanted—with commercial success. For large establishments there is evidence based on practical use that the Upward, the Holmes, and the Lalande batteries are suitable, that is where cost does not stand in the way. It has not, however, been shown to the satisfaction of the author that any one of them can be used economically for lighting the principal rooms in more modest residences; in a word, for the general public. The author has been met by some with the statement that the general public could at the present time be supplied with electric lighting by primary batteries as cheaply as they are with gas, but that until clients from the wealthier classes, to whom expense is not an object, have been exhausted, prices will not and should not be lowered. The author conceives this course to be a mistake, for the process of exhaustion will be slow. Oil lamps and candles are still used in the principal rooms in numbers of mansions, and in the residences of the upper classes, and will continue to be used owing to their effective appearance as works of art—as many of them are—and to the greater purity of the air resulting from the combustion of oil as compared with that of gas.

To popularise the electric light—and to popularise it is the only way to make it pay—it must be cheap and efficient. By cheapness is to be understood either a small first cost and a correspondingly small cost for maintenance, as in the case of a battery placed in the house, or a moderate charge for the supply of the current, as in the case of a central distributing station. The lamps must be adaptable to the present gas fittings, and the cost of the light must be but little in excess of that of the gas of the district. The author does not for one moment ignore the advantages of the electric light from a hygienic or a domestic point of view, he is but too familiar with the unpleasant atmosphere which results from burning gas even with the best burners and in ventilated rooms, although his lucubrations are generally conducted by the aid of an oil lamp. The general public, however, will in the main continue to use the present ordinary methods of illumination, however defective they may know them to be, rather than adopt any new system which entails extra cost, however satisfied they may be that positive advantages are to be gained from it. Men will weigh the extra cost against the extra advantages, and in the majority of cases the former will be allowed to outweigh the latter.

That there are merits in many of the primary systems described—that is, those which have survived their introduction to the public—there can be no doubt, some possessing points which are absent in others. And be it remembered that the list of primary batteries is not exhausted by those described by the author. It might therefore be desirable that a fusion of interests should be effected, and that a committee of independent electricians, chemists, engineers, and sound commercial men, be formed to practically test each battery to destruction. Out of the results might be formulated a system which would meet all the requirements of the general public, and which might eventually be the means of saving the proprietors of those systems which fell short of the mark from absolute loss. The results of this method of applying the doctrine of the survival of the fittest would, perhaps, press the least inconveniently upon those doomed to suffer by this inexorable law. Of course the author can quite understand every inventor present assuring himself that he is not going to be an absolute loser, but that he is going in to win. The author can only sincerely hope it may be so. Every battery represents a considerable expenditure of time, money, and anxious thought, and every inventor deserves, if he does not achieve, ultimate success.

DISCUSSION.

The PRESIDENT said his first duty was to invite the audience to join with him in according a hearty vote of thanks to Mr. Nursey for his paper. The subject was one which interested them all, either with reference to their special studies or as householders.

The acclamation which greeted these remarks signified the concurrence of the audience. Thereafter the President called upon

Mr. PREECE, who said his remarks were not intended in the least degree to be made in a critical spirit, and he hoped it would not be thought that they were the outcome of an unfair one. He must at once confess that he was, to a certain extent, an opponent to the introduction of primary batteries for the purpose of distributing light in houses. There were few who had had more experience as to the behaviour of primary batteries than himself; for 34 years he had been acquainted with their working, and he was quite sure that any attempt to utilise them for any such extensive purposes as lighting mansions or houses would end in disastrous failure. Still there were very valuable purposes to which primary batteries might be applied with advantage, and he hoped with pecuniary success. Mr. Nursey had introduced them to 16 or 18 different batteries, but even that number did not include all the various types which had been thrust upon the public during the past few years; these were so numerous that the subject of primary batteries had become nauseating. Most batteries had two or three rather peculiar and distinctive features. They were almost invariably surrounded with a halo of mystery: there was a depolarising agent which was a secret, an acid, or a solution that was hidden in the atmosphere of a Greek or Latin word, the result being that all that was known about these batteries was derived from the "high-falutin" statements that appeared in prospectuses and supplied descriptions in the papers. Amongst numerous failures, however, there had been one or two successes. One very promising battery to which Mr. Nursey had alluded, and which he (Mr. Preece) at one time thought would certainly make a stir, was the Holmes-Burke battery. Another, which was a distinct departure, was the Upward, and why that battery had not been more practically tried and developed he was unable to understand. It seemed to meet a want for something just between the point where a gas engine or secondary battery might be introduced, and that where a single small battery might be employed for mining or other similar purposes, and it had not been so well received and developed as it deserved. Mr. Nursey in his paper had given a great deal on the theoretical side of the primary battery question; but was there a gentleman in that room who could tell them the practical result of twelve months' work? Could he give the description of six or even of three month's work? That was what practical men wanted more than anything else; they wanted actual figures showing the result of practical working. They had had estimates from Mr. Nursey, but one serious omission in those estimates was the labour involved in charging, cleaning, and maintaining. His experience was that the cost of zinc and the cost of acids formed a small part of the cost of working batteries; the chief expense was in attending them. They had heard from the author of the paper what they had frequently heard from others, that many of the batteries invented would pay for themselves by means of the bye-products. They had heard of one battery which generated when working something which would make a splendid insulator; afterwards they learnt that the inventor found that oxy-chloride of zinc, which was to have been the insulator, did not pay the cost of collection. In the Post Office they had some five or six hundred thousand batteries, and the products of this vast number were necessarily very weighty; but they had never yet paid the cost of their collection. The field in which primary batteries were going to make a stir was not in house lighting, but in supplying safety lamps to those who endangered their lives for the comfort of the rest of the world. There was no greater want in this age than that of a handy portable and convenient light which men could carry about with ease to themselves and safety to their fellow workmen. Very few collieries yet employed the electric light, but he had visited two or three of them, and what he had seen persuaded him that the day had come when electric lamps must be used for mining purposes. It was interesting to know that 2,600 lamps had been ordered for collieries in the neighbourhood of Cardiff, and others would soon follow in introducing this most useful and necessary reform. Amongst the batteries described in the paper was one most valuable form—the Union—which had not come to the front so much as it deserved to do; there was another which he was sur-

prised that Mr. Nursey did not describe, which possessed points of considerable merit, known as the Schanschieff. He had experimented upon the latter during the last 12 months or so. It was an extremely simple battery, consisting, if he remembered rightly, of zinc and carbon in a very densely saturated solution of sulphate of mercury. Sulphate of mercury, they all knew, was the exciting liquid used in the Marie Davy battery, but that was a cold solution, and the density was very low indeed. But Mr. Schanschieff had adopted a process by which the mercury itself was dissolved in hot sulphuric acid, and the result was that the density was very great, something like 1·6; the electromotive force was very high, 1·4, he believed, and the internal resistance was very low. This battery worked a good many hours with a very constant current, and it compared very favourably with some of the batteries which had been described. The Eclipse battery seemed to give a nice, steady light, but he would like to hear someone connected with that battery explain the difference between it and the Holmes-Burke battery. From Mr. Nursey's descriptions they appeared to be pretty much the same, excepting as to size. He believed those gentlemen who were striving to introduce primary batteries for domestic lighting had an almost herculean task in hand, whilst, on the other hand, those who were utilising them for the purposes of the miner were working in the right direction, and the whole theoretical, practical, scientific and commercial world would hail with the greatest delight the man who would put into the hands of the miner a true and practical safety lamp.

Mr. MARCH, accepting Mr. Preece's challenge to describe the practical working of a primary battery for a period of more than a few months, stated that more than two years ago he attended the installation in Leicestershire of an Holmes-Burke battery to light forty 10-candle lamps. That installation had worked with perfect satisfaction to its owner ever since, and was running at that moment. The cost of lighting by means of the primary battery must, of course, be greater than that of gas. He put down the cost of the Holmes-Burke battery at something like double the price of gas at 3s. or 3s. 6d. per thousand feet. He might mention that Mr. Yarrow had had an installation running in his house for nearly three years with perfect success; and the late Sir Francis Bolton had one in his house for nearly two years, which was still kept up by Lady Bolton. He trusted that this was sufficient evidence that the primary battery was not entirely a failure, as Mr. Preece seemed to suppose.

Mr. CLIFTON, who stated that he represented the Eclipse battery, and had formerly been employed upon the Holmes-Burke, said the distinction between the two was very great. The amount of nitrate of soda consumed was 100 per cent. less in the Eclipse than in the other, and the labour entailed by maintenance was considerably less. The size of the Eclipse was about 500 per cent. less in every way, and the manipulation of it could easily be undertaken by any ordinary servant. There was no costly mercury to spill, and very little or no fumes was given out. They used nitrate of soda and sulphuric acid, he would admit, but in very different proportions from those in the Holmes-Burke battery. When the battery was used as a miner's lamp, it gave a very fair amount of light, and its cost placed it within the reach of every miner. Its weight was 5 lbs. against the 7 lbs. of the Swan miners' lamp, and its price was 14s., that of the Swan being £2 10s.

Mr. MARCH observed that the owners of the Holmes-Burke patents considered that the fluid employed in the Eclipse battery constituted a direct infringement of those patents, and the Eclipse Company had been notified to that effect.

Mr. WALSH said he was the owner of the Eclipse patents, and it was true that he had been notified three months ago that the Holmes-Burke people considered the Eclipse an infringement. He had used the lights on the Road Car Company's 'buses for over six months, on the Great Western Railway for over eight months, and they had been inspected in the House of Commons. The lamp had been adopted by the Conference of Miners at Edinburgh. He had given notice to Messrs. Holmes-Burke that he was prepared to defend his patents.

Mr. O. C. D. ROSS said his battery was a zinc and carbon one, and the only mystery there had been in regard to the solution was that he had occasionally called his oxidising liquid "Eureka"; but he was quite prepared to explain what it was. It was a very economical one, being composed of three parts of muriatic acid, three parts of water, and one part of any strong oxidising agent. He generally used a peculiar kind of fuming nitric acid, that was to say, that which was sold as nitrous. He had sometimes used nitrate of soda mixed with the muriatic acid, and this was cheaper. In the Eclipse and Holmes-Burke batteries nitrate of soda was mixed with sulphuric acid. He did not think the battery gave quite so constant a current with the mixture of nitric acid; but practically there was very little difference between nitric and hydrochloric acid. With regard to the application of batteries to house lighting, he had had experience in lighting large houses in Queen's Gate, and he wished to say something about that in order that it might be seen that there was no insuperable difficulty. If they had a battery composed of a number of cells which had to be filled or emptied separately no domestic servant would be able to attend to it. His battery had hitherto been one which enabled him to draw off the liquid from or put it into a dozen cells together by the same motion. He had now improved upon that, and it would surprise those who had had anything to do with primary batteries—Mr. Preece, as much as any one, probably—to learn that he had found a way of putting all the cells together into one reservoir of liquid from which they fed themselves. The battery could now be put in a much smaller space, it was much more manageable, and altogether was such as any servant might be trusted to daily refresh. One thing which was more than the domestic servant could do, was keeping the elements in order. It was a very difficult thing to keep the carbons in such a state that they would never deteriorate, because if they were of sufficient size to allow of, say, 20, 30 or 40 lamps being lighted, they were necessarily composed of a number of parts which must be kept together by metal, and if that metal was affected by nitric acid, very soon the carbons were unfit for use. His carbons were the waste rods from the manufacture of carbons for arc lighting. If batteries were made so as to allow of domestic servants attending to them without difficulty, there was no doubt whatever that they might be used with very fair economy. They cost a great deal less at starting than any form of dynamo or accumulators, and consequently they were to a very large extent adaptable to fairly well-kept houses; he did not say to the poorest houses, because he did not think it was possible to get electric light as cheap as gas, but very nearly.

Mr. FERGUSON said he was interested in the Lalande battery, and he thought he was right in saying that in the year 1886 they ran about 1,000 lights with that battery. Amongst other places, Lord Onslow's and Lord Wenlock's town houses were lighted up as well as Lord Wenlock's country residence. Exhaustive tests had been made both by English and French scientists, and went to show that the battery was a very constant one. The only point in regard to which there was any doubt was as to the getting back of the zinc; this had been done, and they were now getting the zinc back in a metallic form. He hoped to be able shortly to send Mr. Preece a sample of great purity, which would be specially made for Post Office purposes to prevent local action. If Mr. Preece would test it he (the speaker) thought he would be couvinced both that house lighting by primary batteries was possible and that the residual products were of value.

Mr. UPWARD stated that his battery had been employed at the Manchester Exhibition, at University College, Liverpool, at the offices of Messrs. Woodhouse and Rawson in Queen Victoria Street, and by the Government of Valparaiso. When they began they had a number of small cells joined up in series. Although that worked thoroughly well and was reported upon by Dr. Lodge, it occurred to them afterwards that it might be simplified very much. The newer form contained two, four, or six, or any small number of cells instead of the large number originally used. The object was to get over the large number of chlorine connections, which of course were difficult to make. The present battery had only been on the market a few months, and he thought they had made a very fair start.

The EARL of GALLOWAY, called upon by the President to speak, said he knew very little about primary batteries, but gave some interesting particulars about the use of secondary batteries by Mr. Elieson on his electric locomotion.

Mr. BINSWANGER endorsed Mr. Preece's remark that primary batteries had a certain use, but that that use was limited. There were a few exceptions, such as the Holmes-Burke and the Upward, but even taking those into consideration, he maintained that primary batteries would not do for lighting houses. The utmost they could expect from them was that they would give a small light for reading, that they might be employed for miner's lamps, as portable lamps generally, or for medical purposes. His intention in becoming connected with primary batteries was more modest than those of most people. There were two kinds of primary batteries, those which used depolarising acids and those which used salts. By using salts you could have a battery that might be left for a long time without any attention. If you used acids you had to give the battery a great deal of attention, and the cost of attention was very great. The Pollak battery was one of the first in which a salt was used as a depolariser, but like all others using salts its E.M.F. was very small. Low E.M.F. was one cause why such batteries as the Lalande and others which had been mentioned had no practical use, although at first sight they might seem very advantageous, and it was the reason why he (the speaker) had been obliged to give up the Pollak battery. He was now interested in a small battery which was not very pretentious, but which would, he believed, do what it was intended to do—it would give a small light for a short time. This was the Friedlaender battery. Mr. Friedlaender had not invented anything very great; in fact, nobody had in connection with primary batteries. Thirty years ago almost everything they now knew was foretold, but undoubtedly great improvements had been made with regard to mechanical details. The cheapening of chromic acid had given primary batteries more chance of success; chromic acid and nitric acid were the best depolarisers, for they allowed the use of more oxygen than any other depolariser. But chromic acid was so dear until lately, until the strontium process was invented, that its use was quite impracticable. Only a few doctors used it for their laryngoscopes, not minding the payment of 4s. or 5s. a lb. for it. Now it could be obtained as cheaply as, or cheaper than bichromate of potash. Mr. Friedlaender had certainly produced a battery which had some chance of success. His (Mr. Binswanger's) ideas did not go far, so he would not promise very much. The arrangements for lifting the elements out of the fluid was very ingenious, and while he did not claim for the battery that it contained anything new, he thought it was an improvement upon some previous forms, and was capable of good service as a miners' lamp or for table purposes.

Mr. HEARSON said he was present on behalf of Lord Onslow, who wanted to know all that was to be learnt about primary bat-

teries. His lordship had for some time had his house lighted by means of an oxide of copper battery which produced sulphate of lead. That battery was at present out of order, and Lord Onslow wanted another to replace it, and if there was a good one to be got, he (the speaker) was commis ioned to buy it. The battery was put in in opposition to his (Mr. Hearson's) wishes, for he was of the same opinion as Mr. Preece and Mr. Binswanger that all forms of primary battery were practically useless for electric lighting where a number of lights were required. The bye-products of the battery were to have been collected periodically, but no collection had yet taken place, and the lights had gone out. He was afraid he should go away from that meeting with the same impression with which he came, namely, that there was nothing at present to go into the empty coal-cellar to take the place of the battery which had broken down.

Mr. D. G. FITZGERALD, speaking as an electrician, and not as an inventor of a secondary battery, said he had had rather more than a quarter of a century's experience of various forms of batteries. He could only say that he, in common with a number of other electricians, had been simply astounded at the statements put forward on behalf of many primary batteries, batteries which had been disinterred from the limbo of past failures, which were experimented upon 25 or 30 years ago, and at that period condemned. He must except from these strictures, however, the chlorine battery of Mr. Upward, and also the Lalande-Chaperon battery, which had some extraordinary properties, and which in a higher degree, perhaps, than any other, possessed the capacity of supplying large currents, being condemned only by its small E.M.F. The primary batteries which had been brought forward for the most part were, as Mr. Preece had said, surrounded by a halo of mystery. A great deal of time, and also a great deal of money, would be saved if, in considering any primary battery, they went back to fundamental principles. He had sometimes heard the question asked: How much zinc and how much iron are consumed in your battery? and the answer was very vague: "Scarcely any action at all on the elements!" It would be perfectly scientific to reply, "In that case there could be scarcely any electrical supply!" In order that the members of that society might have the means of extricating themselves from this halo of mystery and of checking certain statements, he had jotted down certain electro-chemical equivalents for the horse-power hour electrical. If they used zinc in a battery they could not consume less than 2·02 lbs. divided by e, the E.M.F. of the battery; if they used lead they could not consume less than $\frac{6{\cdot}38 \text{ lbs.}}{e}$; iron, not less than $\frac{1{\cdot}73 \text{ lbs.}}{e}$; sulphuric acid, $\frac{3{\cdot}02 \text{ lbs.}}{e}$; nitric acid, $\frac{3{\cdot}88 \text{ lbs.}}{e}$; chromic acid, $\frac{2{\cdot}06 \text{ lbs.}}{e}$; and peroxide of lead, $\frac{7{\cdot}36 \text{ lbs.}}{e}$ These formulæ evidenced the great importance of the E.M.F. of the cell; the consumption of material was inversely as that value. He was inclined to question whether any battery consuming zinc could be put forward as an economical source of electricity, because even if the E.M.F. were as high as 2 volts there was a consumption of 1 lb. of zinc, and the cost of that was a great deal higher than they would need to pay for the horse-power electrical. One farthing's worth of coal, 2¼ lbs., would produce the equivalent of lead in any secondary battery reduced from sulphate and simultaneously the equivalent of peroxide of lead; that was to say, at a cost considerably under ¼d., they could by the agency of the steam engine obtain an horse-power hour. With this fact staring them in the face, they could scarcely look with any degree of patience on the batteries consuming large quantities of comparatively expensive materials, if they were put forward as economical batteries for use on a large scale. If they were intended for small applications in which the expense was not a matter of moment, then they could bear with them, but to suppose for one instant that any of the batteries that had been put forward, outside of the generation by means of the steam engine, could be used economically on a large scale was altogether out of the question. He hoped the figures he had given would enable the members of the society to check any statements which required to be brought to the test.

Mr. RAWSON said the Upward battery was the result of a good many years of hard work, and the reason why they had not done more with it during the past year was that they had a name to keep up; they were in a different position from many primary battery inventors, who, although he meant no disrespect to any of them, did not care what happened to their batteries after they had gone out of their hands. His firm was anxious to avoid difficulties with its customers, and consequently wished the battery to be as perfect as possible; therefore so much had not been done in the way of putting up batteries as might have been. Mr. Upward had for the past four years been gradually working out the difficulties one by one, and that was the only way to work with primary batteries. After three months' working one difficulty cropped up, after another three months another had to be got over, and so on. They had some four or five batteries running now, and he was happy to say that they were fairly successful. Mr. Stetson had come over from America to see the various primary batteries in this country, and his remark regarding the Upward battery was:—"I am thoroughly satisfied that the thing is perfectly practicable, and the only point is the question of what it costs. You seem to have got over all the difficulties." With regard to cost, that was the question they were attacking now. It was a very large one, and depended, of course, to a great extent upon the cost of material. They proceeded upon the assumption that they could not utilise the residual products at all. Chlorine was one of the cheapest gases for the purpose of a primary battery, and they had already reduced the cost of material by from 50 to 70 per cent. To give some idea of the demand which existed for a good battery, he might state that last week they refused an order for a battery four times as large as the largest they had yet put up. They did not like to take the order, preferring to wait another six months, when they might work out further improvements. He quite looked forward to 12 or 18 months' hard work with the battery before getting it into a form when they could say it was fit to take the place of a dynamo or gas-engine for lighting houses with 50 or 100 lights. There were many places in London where people would give three or four times the price of gas to get the electric light, and consider it cheap at the price. There were other batteries beside the Upward which could be operated for house-lighting successfully if the mechanical details could be worked out. This question of mechanical details was a most important one. For many purposes, such for instance as a miner's lamp, or for placing in bank cellars, it was not so much a question of price; it might in the latter case be five or eight or ten times the cost of gas, and yet, if the mechanical details were satisfactory, people would be glad to have the electric light. They had spent many hundred pounds in working out the mechanical details of batteries for different people. They had spent a good deal of time in this way over the Schanschieff battery, and he (Mr. Rawson) quite confirmed what Mr. Preece had said respecting that battery. For the last three years they had been working upon it, and certainly he thought it was one of the most practical batteries of the present time.

Dr. FLEMING said there were several statements with regard to primary batteries that recurred with ever-perennial freshness. One was about the waste products being so excessively valuable. It seemed to be forgotten that the same law held good in this as in other things, that the price was regulated by the ratio of supply and demand, and that if a quantity of any material was thrown into the market the price would necessarily fall. It was not by any means certain that if, say, oxide of zinc fetched a certain price it would continue to do so if tons of it were thrown into the market and the supply was in excess of the demand. There were one or two batteries which had not been mentioned by the reader of the paper. There was a primary battery, or rather a combination of a primary and a secondary battery which was very effective in the steadiness and in the high value of the E.M.F. It was made by simply taking a zinc plate and the positive plate of a secondary battery and placing them in a dilute sulphuric acid; by this means they could get a battery which could be left for a considerable time and always be ready for use, its E.M.F. being 2½ volts. With regard to chromic acid in batteries, he had had a great deal of experience in that matter, and he was very much surprised to read in the *Times* that morning an account of a battery using chromic acid, which read as though chromic acid had only just come into use for the purpose. He had been in the habit of using it for the past two years. Chromic acid was preferable to the ordinary solution, but, at the same time, no chromic acid battery in which carbon and zinc were employed possessed any constancy of E.M.F. The solution was rapidly deteriorated or deoxidised in the neighbourhood of the carbon unless there were some arrangement for stirring the fluid. More than that, the chromic acid acted with such rapidity upon the zinc that five times as much was used as contributed to the production of the current. Mention had been made of the Swan miner's lamp. He was not there as the representative of the Edison-Swan Company, but most of those present were aware of his connection with that company, and he begged to say that the figures put forward by the representative of the Eclipse battery in relation to the Swan battery and lamp must have been evolved from his own inner consciousness, for they were certainly not communicated to him by the Edison Company. The latest form of mining lamp, which was the outcome of the work done on the subject in the Edison-Swan factory lately, was upon the table, and no doubt many gentlemen present would be interested to see the practical form which the lamp had assumed, when he thought they would consider that there were many advantages to be considered besides that of simple weight.

The PRESIDENT announced that Mr. Nursey would send in his reply to the discussion in writing, and it would be printed in the proceedings of the Society.

With votes of thanks to the author of the paper and the President, the meeting then terminated.

LEGAL.

Sir W. Thomson v. Batty.—In this case the plaintiff, Sir William Thomson, was the proprietor of a patent for an invention consisting of improvements in the mariner's compass and in appliances for correcting its errors. After several years of experimenting and investigation on land and sea, the plaintiff had invented a peculiarly light compass card with small needles and radial supports of both needles, which, with other things, formed the subject of a patent granted to him in the year 1876, and that compasses made according to this invention had for the last 11

years been very extensively used in the navies of this and other countries and by British and foreign shipowners. In 1885 the plaintiff, for the first time, discovered that the defendant, a nautical instrument maker, carrying on business at Liverpool, was making a compass card which, it was alleged, was an infringement of the plaintiff's patent, and that he had issued a circular containing a drawing of the compass card made by him and a list of wholesale prices, together with testimonials from various people who had used his instruments. A correspondence then took place between the plaintiff's agents and the defendant, and proceedings were threatened, but were not actually taken until a short time ago. The reason given by the plaintiff for this delay was that he was not aware that the defendant was actually selling his compass cards until July last, when it was brought to his knowledge that the defendant was making and using the compass cards complained of for the purpose of sale. He then commenced his action against the defendant, and now applied to the court for an interim injunction restraining the defendant until the trial from infringing his patent in any way. Mr. Aston, Q.C., and Mr. W. N. Lawson appeared for the plaintiff; Mr. Graham Hastings, Q.C., and Mr. Chadwyck Healey for the defendant. Mr. Justice Stirling, without calling upon counsel for the defendant, refused to grant an injunction. He said that, according to his view of the practice, when the proprietor of a patent knew that it was being infringed, it was his duty to come promptly to the court. Here, although the plaintiff knew in 1885 that the defendant was making compass cards which he thought to be an infringement of his patent, yet for some reason or other he said that he was not satisfied that there had been such an infringement as would entitle him to bring an action. His Lordship thought that any court having before it the circular which had been issued would come to the conclusion that the defendant was making the compass cards for sale. Having regard to the circumstances and to the correspondence which had taken place between the parties in 1885, he did not think that this was a proper place for an interlocutory injunction. No order would be made upon the motion, and the costs would be reserved to be dealt with at the trial.

Smart, Black & Co. v. the United Telephone Company, Limited.—In this action, heard before Mr. Justice Mathew and a special jury on Monday, the plaintiffs, who carried on business as manufacturers at 32, London Wall Avenue, asked for damages which they alleged had been caused by one of the plaintiffs' telephone wires falling upon their roof. They also asked for an injunction to prevent the defendants carrying their wires over the plaintiffs' premises. The defendants, while admitting that one of their wires had been broken by an excessive fall of snow, denied that it had caused the damage complained of, and they alleged that any damage caused to the plaintiffs' roof was caused by the snow falling off their roof. Mr. Crump, Q.C., and Mr. Moreton were for the plaintiffs; and Mr. F. S. Moulton, Q.C., and Mr. Daniel appeared for the defendants. On the morning of January 28th last there had been a very heavy fall of snow, which had broken one of the defendants' wires running over the plaintiffs' premises, and which had been put up without their consent. This wire had run at right angles across the roof, and was found lying along the roof directly underneath where it had been suspended. The plaintiffs' case was that when it had suddenly snapped its end or ends had, when rebounding and vibrating from its fall, carried away portions of their roof guttering. This theory they sought to support by certain marks upon the snow upon the roof. The defendants, on the other hand, contended that the position in which the wire had been found completely answered the plaintiffs' theory, and they (the defendants) attributed the carrying away of the guttering to an excessive weight of snow pressing and slipping on to it, and its being very insecurely fastened and supported. The claim for an injunction was ultimately abandoned, it being stated that the defendants' wire had been removed from over the plaintiffs' premises. In the result the jury found a verdict for the plaintiffs. Damages had been agreed at £300. Judgment accordingly, with liberty to apply for an injunction should the defendants' future conduct render it necessary.

The Electric Light and Railways.—There are three electrically lighted trains now running on the Great Northern Railway, and a fourth is almost completed, and will be at work before the end of the year. The South Eastern Railway Company also has electrically lighted trains running as well as the Brighton Company. The Great Northern trains so far fitted up are used on the suburban and underground service, where superior lighting is of the greatest importance. The carriages of these trains are not required to be separated, no matter what kind of light is used. The company, however, is prepared to electrically light trains from which carriages have to be detached, and to maintain the light in the separated carriages, which of course will carry their own storage batteries underneath. We are pleased to learn that a great extension of train lighting by electricity is now being arranged for by this company.

NOTES.

Electric Lighting of the Isthmian Club.—The new club-house of the Isthmian Club is said to be one of the handsomest in London. It is lighted throughout by electricity, forming part of the installation worked from the central station at the Grosvenor Gallery. The work was most successfully carried out by Messrs. Woodhouse & Rawson, and every satisfaction with the light is expressed by the members.

Vienna Central Station Lighting.—A *Times* telegram states that the event of the day in Vienna on Tuesday was the closing of the Opera, owing to a hitch in the electric lighting. This had been caused by the cracking of some boilers at the central station, but the blame in the matter was said to rest entirely with Baron Besecny and the officials of the Court Intendance, who insisted that boilers of Austrian make should be used at the central station.

The Westinghouse System of Electric Lighting.—"B.J.," writing too late for our correspondence columns, says: "Referring to the article in your last issue, I think Mr. G. L. Addenbrooke has made a slight error in his calculation as to the number of reversals per second. He will find, I think, by referring to them again, that they should read 880 per second, instead of only 680—a difference of 200. He appears to find even elementary mathematics a bad master."

Electric Lighting at the Bank of England.—We are informed that the extension of the installation at the Bank is progressing rapidly. The additional engine power will consist of a 20 H.P. nominal Marshall engine and boiler driving two large Elwell-Parker dynamos. There will also be a battery of Drake and Gorham's accumulators in connection with each circuit.

Electric Lighting at Bristol.—In accordance with a resolution passed by the Bristol Town Council last year, a special committee has been obtaining information concerning all improvements made in the electric light. In March last some of the members visited Taunton to investigate and observe the effect of the system of electric lighting there in experimental operation. Since then the committee have consulted Mr. Preece, who writes: "The question of the distribution of electricity for general electric lighting stands very much in the same position as it did when I last had the pleasure of writing to you. . . . . I do not think that your Corporation would be justified in acting upon your provisional order until the electric light can be produced to compete with you on more favourable terms than hitherto. At the same time I do not think your order should be allowed to lapse, because at any moment such progress may be made that we can act." In view of this advice the committee are of opinion that the time has not yet arrived when any steps can advantageously be taken for introducing electricity for public lighting in Bristol. However, for the reasons assigned by Mr. Preece, they recommend that they should be re-appointed.

Electric Lighting of the "Wild West."—The American Exhibition at Earl's Court having closed, Buffalo Bill with his "Wild West" has moved to the Aston Grounds, Birmingham, where he opened this week. The United Electrical Engineering Company has been entrusted with the contract for the electric lighting, which will be on a scale equal to that which obtained at Earl's Court, and will comprise ten large projectors, each taking a current of 50 ampères, supplied with current from two Victoria dynamos, each large enough to light the total number of lamps by itself.

Telegraph Communication in India.—A telegram to the *Times* from Rangoon, dated November 5th, announced that for the previous ten days telegraphic communication with India had been seriously interrupted.

Lighting of the Union Bank of London.—In connection with this installation, which will shortly be completed, Messrs. Elwell-Parker have supplied two 12-unit dynamos and 106 large cells.

Railway Telegraphs.—Both the Midland Railway Company and the Cheshire Lines Committee are advertising for tenders for telegraph materials, instruments, wire, &c. Tenders for the Midland Company should be sent to the Secretary of the General Stores Committee, Derby, by the 16th inst., and for the Cheshire Committee to the Stores Department, Warrington, by December 3rd.

Telephony in Austria.—A project of long standing concerning the management of telephone exchanges by the State, says the correspondent of *Industries* at Vienna, has at last been carried out. The Government offers to connect subscribers to central telephone exchanges in various towns and with the telegraph offices, in order to facilitate telephonic business, and also the transmission and receipt of telegrams by telephone. The charges are moderate, and in the majority of cases will not exceed 100 florins (£8 10s.) per annum. This change in the administration of telephones has been received very favourably by the present subscribers to the private telephone exchanges, who are all anxious to be connected with the State exchanges. As a consequence there has been a drop in the value of the shares of the private telephone companies.

Telephone Wires at Bournemouth.—The Bournemouth Commissioners have received a letter from the Western Counties and South Wales Telephone Company, promising that their recommendation in favour of telephone wires being carried underground in future should receive careful consideration. There appears to be nothing in the original agreement with the company to compel it to carry the wires underground, and on the question being incidentally mentioned at the last meeting of the Commissioners it was pointed out that it was a serious matter to suddenly ask the company to place its wires underground, as it would increase the cost to the subscribers something like fourfold. The exchange had proved of great advantage in the town, but it would have never been established had the Commissioners stipulated in the first place that there should be no overhead wires.

Telephone Wires at Hastings.—An exciting discussion took place in the Hastings Town Council last Friday respecting the application of the South of England Telephone Company to run telephone wires overhead. Even the Government, it would seem, is not permitted in this very particular borough to put wires overhead except where absolutely necessary, and great opposition was expressed to the granting of the telephone company's application. The Roads Committee reported against it, but an amendment to the report was moved in favour of granting the permission asked for. Several councillors said it was only a question of pounds, shillings, and pence, and telephone wires could be run as well underground as overhead. Eventually 10 voted for the amendment and 13 against it, the verdict therefore being against the overhead wires. A similar application from the Electric Lighting Company was also rejected.

Government and the Cables.—The Central News states that the Government have resolved to keep under their direct control all telegraphic cables between Great Britain and France, Holland, Belgium, and Germany as soon as the present concessions have expired. As far as Holland, Belgium, and Germany are concerned there has been no difficulty. These countries were ready to readjust their telegraphic arrangements with England, and contracts have already been signed between Great Britain and the Dutch, Belgian, and German Governments, which will, when the present concession expires, place in the hands of the Post Office a monopoly of telegraphic communication. The Post Office authorities have already practically decided to lay additional cables from the East Coast to Rotterdam and Amsterdam, and thus, while a greatly accelerated service will be assured, it is probable that rates will be reduced, provided the International Telegraphic Union consents thereto. A difficulty, however, has arisen in respect to France, which, after prolonged negotiations, consented to renew the concession to the Submarine Telegraph Company for a further period of 15 years; but the Postmaster-General vetoed the arrangement, and declined to be any party to the renewal, pointing out that as the Government had agreed to work with Germany, Holland, and Belgium, they could not consent to an independent company dealing with messages from and to France. Moreover, as the British Post Office has a monopoly of all telegraph wires in this country, it would prevent the agreement referred to from being carried out. The authorities, however, were quite willing to buy the cables and plant of the Submarine Company at an electrician's valuation, but they would give nothing for the "goodwill." Against this decision the Submarine Company appealed to the Treasury, and some pressure was brought to bear upon the Government to allow the French cables to remain under the company's management. The French Postmaster-General personally came to London, and is still here. No later than Wednesday Sir Julian Goldsmid, the chairman of the Submarine Company, had a long interview on the subject with Mr. Goschen. The Chancellor of the Exchequer, however, could hold out no hopes of overriding the decision of the Post Office authorities, and little doubt is entertained that the Treasury will grant the necessary funds which will enable the Post Office to accomplish the work. This resolution on the part of the Post Office will, it is anticipated, not only tend towards a vastly-improved and probably cheaper telegraphic communication with the Continent, but will also prove to be a profitable undertaking for the Government, as the earnings of the Submarine Company have always enabled them to pay a large dividend. The Post Office is prepared to employ the latest and most approved fast-speed instruments and all modern appliances to ensure the most rapid telegraphic communication between this country and the Continent.

Eastern Cables.—The Eastern Telegraph Company notifies that it has opened for traffic a new cable between Porthcurnow, in Cornwall, and Gibraltar, Malta, and Zante, thus putting Greece and Turkey in direct cable communication with this country. The same company also notifies the opening of a new telegraph station at 37, Holborn Viaduct, where telegrams will be accepted for transmission to all parts of its system.

Dangerous Wires.—Several private wires having been recently erected at Littlehampton at an insufficient height from the ground to admit of the fire-escape passing underneath, the Local Board passed a resolution at their last meeting, requesting that the wires should be raised to at least 32 feet.

Adelaide Exhibition.—Messrs. Ransomes, Sims and Jefferies, Limited, of Ipswich, have been awarded the First Order of Merit at this exhibition for their exhibits, which include portable steam engine, vertical engine and boiler, single and double furrow ploughs, patent chilled ploughshares and horse-rakes.

Electric Light Signalling.—American papers state that Mr. Edison has again brought to notice the subject of distant signalling by means of throwing the rays from the electric light upon the clouds and by a combination of short and long flashes, somewhat similar to the Morse telegraph code, communicating from one station to another some 20 miles away. To demonstrate the practicability of this scheme it is proposed that it should be tried aboard any of the Government vessels fitted with the electric search light.

The Affairs of W. E. Irish.—The trustee of the estate (in bankruptcy) of William Edwin Irish, lately of Sunderland, but now residing in America, has applied for his release, giving the usual statement of the position of the estate. By this statement it is seen that the realisation is not entirely in accord with what was foreshadowed by the bankrupt. The latter estimated that the estate would produce £5,306 17s. 7s.: it actually produced £161 17s. 2d., out of which, after payment of necessary expenses, a balance of £1 17s. 10d. remains with which to provide for postages, stationery, and the closing of the estate. The trustee makes the following remarks: "The book debts are nearly all bad, and were due from persons to whom contra accounts were owing. The items of £4,438 and £430 consisted of inventions patented by the bankrupt; these have turned out quite worthless, and have now lapsed, as certain patent fees were due upon them and have not been paid."

The Wind and the Wires.—The recent gales and severe weather have done comparatively little damage to the telegraph wires throughout the kingdom. We learn from the Post Office that there is no report of failure of communication to any place. The accidents were principally due to fallen trees or broken branches. Copper wires have proved all that was expected of them. One curious accident is reported from South Wales. An arm and insulator bolt were broken and three wires released, owing to the roof of a cattle waggon being blown off a passing train against the pole.

Electric Hoists.—We understand that Messrs. Drake and Gorham has just completed another electric hoist, and that those previously erected have never required the least attention or repairs, though they are in regular daily work. There should be a considerable demand for this class of apparatus in offices where the electric current is available.

Transmission of Power at Craigside.—Lord Armstrong is now engaged in modifying and extending the apparatus used for transmission of power and the lighting of his mansion. The work is being carried out by Messrs. Drake and Gorham, who have also received instructions to install 50 of their largest size cells.

Office Lighting.—The offices of the Northern Assurance Company are being fitted throughout for the electric light. The work is in the hands of Messrs. Drake and Gorham.

The Royal Society.—The following is the list of names recommended by the President and Council of the Royal Society for election into the Council for the year 1888, at the forthcoming anniversary meeting on the 30th inst.:—President, Prof. George Gabriel Stokes, M.A., D.C.L., LL.D.; treasurer, John Evans, D.C.L., LL.D.; secretaries, Prof. Michael Foster, M.A., M.D., the Lord Rayleigh, M.A., D.C.L.; foreign secretary, Prof. Alexander William Williamson, LL.D.; other members of the Council: Sir William Bowman, M.D., Henry Bowman Brady, F.L.S., F.G.S., Prof. Arthur Cayley, D.C.L., LL.D., W. T. Thiselton Dyer, M.A., Prof. David Ferrier, M.A., M.D., Edward Frankland, D.C.L., Arthur Gamgee, M.D., Prof. Joseph Henry Gilbert, M.A., Prof. John W. Judd, P.G.S., Prof. Herbert M'Leod, F.I.C., William Pole, Mus. Doc., William Henry Preece, M.I.C.E., Admiral Sir George Henry Richards, K.C.B., Prof. Arthur William Rücker, M.A., the Earl of Rosse, D.C.L., LL.D., and Sir Bernhard Samuelson, M.I.C.E.

A Carbon Case.—We are informed that an action is pending in which Mr. D'Humy is sued by Messrs. Sharp and Kent for recovery of a sum of over £100 for carbon plates supplied for his battery. Mr. D'Humy, we understand, sets up a counter-claim for damages (£1,000) upon the plea that the goods were bad.

Society of Arts.—On November 23rd Prof. Silvanus Thompson will read a paper on "The Mercurial Air Pump," and for a paper on "The Measurement of Electricity," by Prof. George Forbes, F.R.S., no date has yet been fixed. Two juvenile lectures on "The Application of Electricity to Lighting and Working," by Mr. W. H. Preece, F.R.S., will be given on Wednesday evenings, January 4th and 11th, 1888.

The Stockport Gas Engine.—This engine seems very rapidly coming into favour. We hear that seventeen were sold at the recent Brewers' Exhibition at the Agricultural Hall.

A Watch Thermometer.—The very neat and handy form of thermometer shown by the figs. (in exact size) has recently been brought out by Mr. M. Immisch, of Malden Crescent, Kentish Town. The chief advantages of this instrument, which is like a miniature watch, being a little smaller than a florin piece, are the readiness with which the temperature may be read off, and its comparative freedom from liability to injury. The action depends upon the movement of a white metal tube

filled with an expansive liquid; the tube opens or contracts as the temperature rises or falls, and this motion is transmitted to the pointer by means of a rack and pinion system, as in an ordinary aneroid barometer. A button, placed within the pendant ring, when pulled out, fixes the pointer in the position to which it has moved, so that after a temperature has been taken the value of the latter can be read off at leisure. The instrument must, we think, be a very useful one for taking the temperature of dynamo coils.

Woodhouse and Rawson, Limited.—We have received the following communication in reference to our remarks regarding an utterance which struck us as peculiar at the meeting of the new company of Woodhouse and Rawson, Limited, last week:—"With reference to the editorial remarks in your last issue on the report of this company's statutory meeting, I am desired by my directors to say that the inference you draw from the chairman's remarks is not what he intended, or what they believe was generally understood by the gentlemen present at the meeting. The chairman's remarks referred to the statements made in the prospectus, and to a description of the business that was being done. The company's shares are entitled to a cumulative preference dividend of 10 per cent. and one-fifth of the excess profits; and it was the chairman's reference to this, and the prospect of the 10 per cent. being earned in the first year, that was being explained to the meeting. There was not the slightest intention of repudiating any statements in the prospectus, but rather of showing that the business is going on as it was there described.—Yours faithfully, J. SHURMER, Secretary (*pro tem.*)."

"Going for" Sir William.—A respectably dressed man named James Forrester, was last week brought before the magistrates at Glasgow, charged with maliciously breaking four large panes of glass and a fern case at the University. Forrester, whose mind was seemingly unhinged, was stated to have been in search of Sir William Thomson at the time of his apprehension, with the object of chastising him for "raining down a shower of electricity on his head." The magistrate remitted the accused to be dealt with the sheriff.

Personal.—Last month Mr. W. M. Foxcroft, well known in connection with a certain department of telegraph and telephone business, who is past-churchwarden of St. James's Clerkenwell, was presented with a valuable service of plate, a case of fish cutlery, and a framed illuminated address, as a recognition for valuable services rendered during his two years' occupancy of the chair of the Clerkenwell Vestry, and also for exceptional work with regard to the finances of the parish church.

Mr. Upward desires us to state that he is no longer on the staff of Messrs. Woodhouse and Rawson.

Gas Companies and Consumers.—An application was made to Sir James Ingham at Bow Street last week for advice with reference to the action of the Gas Light and Coke Company. Applicant said that for some time past he found his accounts had increased about 100 per cent. Although on two occasions two of the *employés* had inspected the meter and said it was in active working order, he felt satisfied that he had been overcharged. The meter was again tested with the result that it was condemned. He wrote suggesting that the company should estimate the amount due by the corresponding quarters. This was not done, and the supply was discontinued. Sir James Ingham said the company had powers under their Act of Parliament, and the right of appeal depended on the wording of the clauses. He advised applicant to obtain a copy of the Act and ascertain what power the company possessed.

An Electric Car at Paisley.—Mr. James Gibson, electric engineer, of Paisley, has constructed an electric tramway car, and an experimental run was made on Thursday week on the line of the Paisley Tramway Company from Gauze Street to Williamsburgh. The experimental run was considered highly satisfactory. The car is of the ordinary size of tramway cars. Accumulators, to the number of 80 are placed under the seats of the car, and they are capable of supplying current sufficient for a 4 hours' journey. The machinery rests on a bogie, which is placed to the front of, but under, the car, and the bogie also includes the front wheels of the car. The motor makes 1,200 revolutions per minute, and a speed can be obtained of from 4 to 15 miles per hour. When the car is going at the rate of 4 miles per hour, it can be brought to a stop within the space of two feet from the applying of the brake. There are two systems of gear, the one a combination of friction and teeth gear, and the other teeth gear alone.

Miners' Safety Lamps.—The Home Secretary has informed Mr. Ellis Lever that he does not see his way to accepting the munificent offer of the latter gentleman to place £1,000 in his hands to be awarded by the Government in two prizes of £500 each, one for a perfectly safe means of blasting in coal mines, and the other for an efficient safety lamp. The difficulty of applying sufficiently rigorous tests, and the fact that there is no lack of energy or competition amongst those interested, are said to be the reasons for this decision.

NEW COMPANIES REGISTERED.

Armstrong's Electric Light and Power Company, Limited.—Capital: £20,000 in £1 shares. Objects: To acquire the business of electrical engineer belonging to James Tarbottom Armstrong, of 147, Bermondsey Street, S.E. Signatories (with one share each): J. T. Armstrong; Charles King, Parliament Mansions, engineer; * Capt. C. D. Inglis, R.N., 101, Warwick Road, Earl's Court; * R. J. Sankey, 31, Aldermanbury; * F. R. Pike, 20, Trebovir Road, Earl's Court; * W. Bellingham, Streatham Hill; J. S. Blease, 39, Cathcart Road, Redcliffe Gardens, S.W. The signatories whose names are preceded by an asterisk are the first directors. Qualification: £250 in shares. Minimum remuneration: £500 per annum. Mr. C. T. Armstrong is appointed chief electrician of the company for ten years at a salary equal to 10 per cent. of the annual nett profits, provided that £300 per annum be the minimum and £1,500 per annum the maximum. Registered 2nd inst. by Adam Burn & Son, 6, Bell Yard, Doctor's Commons. Registered office: Palace Chambers, 9, Bridge Street, Westminster.

The Engine Company, Limited.—Capital: £100,000 in £10 shares. Objects: To carry on business as manufacturers of and dealers in Westinghouse and other steam engines, machinery and electrical apparatus, and the business of mechanical and electrical engineers. Signatories (with one share each): J. M. Machellan; S. Alley, Polmadie, near Glasgow; * Sir J. D. Mackenzie, bart, 62, Redcliffe Square; * J. M. Stobart, Ryde; * W. Duff Bruce, 8, Champion Park, Denmark Hill; * J. W. H. James, 9, Victoria Chambers, S.W.; * J. D. Gibbs, 13, Warwick Street, Regent Street. Mr. H. W. Westinghouse and the subscribers denoted by an asterisk are the first directors. Qualification: £250 in shares or stock. Registered 2nd inst. by Wynne, Holmes and Wynne, 40, Chancery Lane.

British Watch Company, Limited.—Capital: £100,000 in £10 shares. Objects: To carry on business as manufacturers of watches, clocks, electric bells, batteries, telephones, gas lighters and regulators, and electric apparatus generally. Signatories (with one share each): W. W. Pilkington and R. S. Daglish, St. Helens; C. Spenceley, Knowsley; T. P. Hewitt and W. Lees McClure, Prescot; A. Eccles and J. Musson, Liverpool. Registered 3rd inst. without articles of association by Chester & Co., 36, Bedford Row.

General Zinc Recovery and Lighting Company, Limited.—Capital: £250,000 in £10 shares. Objects: To carry on in all branches the business of an electric light company. Signatories: Hugh A. Fergusson, 4, Wilton Street, S.W.; F. W. Forrester, 66, Mark Lane; Sir W. Vavasour, bart., Tadcastle; J. J. Dunnington-Jefferson, York; J. F. Jackson, Bexley; S. M. Fergusson, Stock Exchange; Thos. Rome, Charlton House, near Cheltenham. Directors' qualification: 25 shares; the signatories are to appoint the first directors. Remuneration: A sum not exceeding £500 per annum, to be doubled when £10 per cent. is paid on the preference shares, and 5 per cent. upon the deferred shares. Registered 7th inst. by Phelps, Sedgwick & Beddle, 18, Gresham Street.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Electro-Metal Extracting, Refining, and Plating Company, Limited.—At an extraordinary general meeting of this company held last month, it was resolved to wind up voluntarily, and Mr. Alfonso Salmon, of 26, Herbert Street, Hoxton, was appointed liquidator at a remuneration of £3 3s., with authority to consent to the registration of a new company to be called the Extended Electro-Metal Extracting, Refining, and Plating Company, Limited. These resolutions were filed on the 2nd inst.

Oppermann Electric Lighting and Manufacturing Company, Limited.—An agreement dated 14th ult. provides for the purchase by the company of the business of electrical engineer carried on by Mr. Oppermann at the Crown Works, Amhurst Road, Hackney. The purchase consideration is £1,200,

payable £500 in cash, and the balance in fully paid shares. Registered office, Astral Works, Blockley, Worcestershire.

Extended Electro-Metal Extracting, Refining, and Plating Company, Limited.—The registered office of this company is situate at Hutchings Street, Millwall, E.

Whitehall Electric Supply Company, Limited.—The registered office of this company is now situate at No. 5, Whitehall Yard, S.W.

CITY NOTES.

The Pilsen-Joel and General Electric Light Company, Limited.

THE sixth ordinary general meeting of this company was held at the Cannon Street Hotel on Thursday, under the presidency of Sir Rawson W. Rawson, K.C.M.G., C.B. The following report was submitted to the shareholders:—

The directors in submitting the accompanying accounts and balance sheet are glad to be able to report to the shareholders that the company's operations for the year ending 30th June, 1887, show a substantial profit, though less than in the year preceding.

This decline, however, is not in itself a feature unfavourable to the future prosperity of the company, as it is attributable to the decrease in sales of electric plant, which for the year just expired amounted to only £1,107, against £3,202 in the preceding 12 months. The royalties received by the company have also been less, but in this respect there seems to be no reason why future years should not show an increase.

As regards the sale of electric plant, however, the tendency in favour of installations supplied on hire by the lighting company is very marked, and the rentals received during the past year amount to £3,485, or an increase over the previous year of £295.

The directors, moreover, are pleased to report that this figure does not embrace important installations arranged for, and in progress prior to 30th June, 1887, but from which no return has been derived up to that date.

It is a fair estimate to put the probable rentals from installations during the current year at from £5,000 to £6,000, and to this source the directors look for substantial and steady profits in the future.

With this view, and owing to the increased accommodation required for the work in connection with the installations, the directors have determined the tenancy of the present factory and offices at Christmas, 1887, and secured upon very favourable terms new premises at 4, Stanhope Street, Euston road, from which a considerable lighting installation is already in progress and promises further material development.

The capital outlay upon the installations is necessarily large, and the directors feel it right to call the attention of the shareholders to the position of the company as regards its available resources.

From the accompanying balance sheet it will be observed that out of the total assets of the company (£33,067) there only remains, after deducting goodwill and patent rights (£25,190) and sundry creditors (£784), £7,093 as working capital.

In addition to this amount a sum can doubtless be obtained from a re-issue of the forfeited shares, in respect of which no step has as yet been taken, but the point must shortly present itself to the shareholders, that if, as seems most desirable, the business of the company is to be extended, further capital must be provided for the purpose.

It has not been thought necessary during the past year to write any amount off the sum at which the goodwill and patent rights stand.

The directors do, subject to the sanction of the general meeting, declare a dividend on the present paid up capital of the company, at the rate of 4d. per share on the partly paid up shares, and at the equivalent rate of 7d. per share in respect to the 100 fully paid up shares. This would absorb £410 19s. 4d., leaving a balance of £244 6s. 11d. to be carried forward.

The Chairman moved the adoption of this report and the declaration of the dividend stated, which was unanimously agreed to.

Mr. G. L. Whateley was re-elected a director, and the auditors, Messrs. Broom, Hays, and Akers were re-appointed.

[A full report of this meeting will be given next week.]

West India and Panama Telegraph Company, Limited.—The report of the directors states that the accounts for the six months ended June 30th show a balance of £23,380. The directors have placed £6,000 to the reserve, leaving £17,380, from which it is proposed to pay 9s. per share on account of arrears of dividend on the first preference shares, leaving £1,826 to be carried forward. The whole of the £50,000 debentures, which fell due on December 31st last, has now been extended for a further term of five years at 5 per cent. per annum instead of 6 per cent.

The Eastern and South African Telegraph Company, Limited.—The directors give notice that on Wednesday, the 16th inst., at 2 p.m., at the company's offices, Winchester House, 50, Old Broad Street, 257 first mortgage debentures of £100 each will be drawn for payment on January 2nd, 1888.

The South of England Telephone Company, Limited.—The directors have declared a dividend of 6 per cent. per annum on the preference shares of the company for the half-year ending 31st October.

London Platino-Brazilian Telegraph Company, Limited.—The directors have declared an interim dividend for the half-year of 2s. 6d. per share, free of income tax.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending November 4th were £2,580, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

The Great Northern Telegraph Company, Limited. The receipts for October, 1887, £25,160; from January 1st to October 31st, 1887, £220,880; corresponding months, 1886, £217,800; and of 1885, £241,640.

The West Coast of America Telegraph Company, Limited. The gross earnings for the month ending October 31st are £3,700.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ended November 4th amounted to £3,492.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1886.

9082. "Improvements in galvanic batteries and in the application of the same to electric lighting and other uses." A. R. UPWARD and C. W. PRIDHAM. Dated July 12. 1s. 1d. Relates to the battery already described in the REVIEW.

9126. "An electric meter." S. C. C. CURRIE. Dated July 13. 8d. Relates to an instrument for measuring the electricity passing through a circuit, this instrument being arranged to act either as a coulombmeter to measure the current, or as a wattmeter to measure the work due to the current. For this purpose the inventor employs an electro-dynamic machine, the armature of which is caused to revolve by the current to be measured or by a known fraction of it. To the revolution of the armature is opposed an adjustable resistance in the following manner. On a horizontal axis, which may be that of the armature or may be an axis geared to it, is fixed a hollow drum containing a quantity of mercury which may be made more or less according as more or less resistance is required. This mercury, tending always to remain in the lowest part of the revolving drum, acts as a brake retarding its revolution. By means of a counter worked by the machine, the number of revolutions in a given time may be registered. The claims are 5 in number.

9696. "New or improved treatment or manufacture of materials for use as the incandescing medium or luminant of electric lamps or for other purposes." T. MACE. (Communicated from abroad by the Vitrite and Luminoid Company, of New York.) Dated July 27. 6d. Claims:—1. The manufacture or production of a material suited for use as the incandescent or luminant of electric lamps or for other purpose, consisting in subjecting a body, base, support, or core, to electric heat in the presence of an organic compound of aluminium, such as ethylate or methylate of aluminium, substantially as described. 2. The manufacture, production, and use of a material suited as the incandescent or luminant of electric lamps or for other purpose, the said material being produced by depositing by the action of electricity a material consisting of or containing carbon and alumina, substantially as described.

10006. "Improvements in electro-motors." A. SCHANSCHIEFF. Dated August 4. 11d. Consists of a cylindrical armature rotating about its axis and with a series of field magnets arranged around it. These field magnets are connected through a commutator with a battery or other source from which the electric current to actuate the motor is derived. The commutator brings the field magnets into circuit successively as each is in a position relatively to the armature to act upon it efficiently. Each field magnet presents a north pole to the armature on one side of the axis and a south pole on the other side, diametrically opposite. The inventor constructs the armature with a series of soft iron wires separated magnetically the one from the other, and each parallel to the axis. More in detail the structure of the armature may be described as follows:—The inventor takes very soft iron wires, say 24 gauge or finer, and places them in a cylinder so that the section at right angles to the axis represents the magnetic lines of iron filings freely falling upon a sheet of paper placed over a magnet. He then fills the cylinder with a diamagnetic substance, metallic or non-metallic, the armature so prepared being in the presence of the field magnets is polarised on rotating around its axis. The field magnets are called into activity successively and maintain the rotary motion of the armature. The claims are four in number.

10404. "Improvements in telephonic systems and apparatus." J. Y. JOHNSON. (Communicated from abroad by A. M. Rosebrugh, of Canada.) Dated August 13. 8d. The object of this invention is to increase the working capacity of and render more efficient metallic telephone circuits in which either two or more telephone subscribers or a telephone subscriber and a telephone operator at each end of a metallic circuit may communicate with each other simultaneously. This is accomplished by firstly connecting a branch line with each end of the metallic circuit and connecting said branch line to either a ground wire or to a return wire or wires, and using differentially-wound telephone apparatus in the metallic circuit, which may be done as described in the specification of the application for patent 4231 of 1886, dated 15th August, 1885, and secondly, by using a telephonic repeater and a switching device at each end of the metallic circuit, and thirdly, by using a compensating device between parallel metallic circuits or between a metallic circuit and a grounded circuit. The claims are 3 in number.

11060. "An improved apparatus for administering electric currents." J. ROOTS. Dated August 31. 8d. Consists of an improved apparatus for testing the amount of or degree of electricity that a person is capable of enduring, a coin being dropped into the apparatus acting as a stop for the purpose of actuating it. The claims are 2 in number.

11101. "Improvements in secondary batteries." T. J. JONES and W. H. TASKER.. Dated August 31. 8d. Claims:—1. The described construction of the positive element of a secondary battery wherein the support for the active material is composed of thin strips of lead partly embedded in and supported by a frame of non-conductive material, the exposed portions of the lead strips being so arranged as to present their edges to the opposite faces of the element and the active material being contained in the intervening spaces, substantially as and for the purpose specified. 2. The construction of the support for the active material of the positive element of a secondary battery, of a thin sheet of lead cut out in the form of connected strips and partly encased in celluloid and the whole corrugated or crimped, so as to bring the strips to the position described and form a grid-like structure, to receive the active material, substantially as described. 3. The construction of the support for the active material of the positive element of a secondary battery of an open-work structure formed of lead wire or ribbon interwoven with strips of celluloid and connected to conductors embedded in celluloid, substantially as specified. 4. The construction of the support for the active material of the positive element of a secondary battery of an open frame of celluloid with lead wires or ribbons stretched to and fro across the apertures of the frame and partly embedded in the celluloid, substantially as and for the purpose specified.

11242. "Improved means for effecting the electro-chemical generation of chlorine in metallurgical operations for the extraction of gold from its ores and for other purposes." D. G. FITZ-GERALD. Dated September 4. 8d. Claim:—The electro-chemical generation of chlorine by means of an anode of peroxide of lead in the form of dense highly conductive layers, plates or masses of any required form, preferably obtained by the means described; the said anode being employed in conjunction with any suitable cathode and with an electrolyte capable of evolving chlorine.

11291. "Improvements in and apparatus or means for electro-plating." R. K. BOYLE. Dated September 4. 8d. Claims:—1. Electroplating by the described dry process, by including the article to be plated and the iridium or other metal to form the plating in an electric circuit, and effecting rapid makes and breaks between the said article and metal, substantially as described. 2. Apparatus for electroplating, as described, consisting of or including a vibrating carrier for the plating metal, an electro-magnet or a mechanical motor, a generator of electricity, and conductors for the current from the generator to the plating metal and article to be plated respectively, substantially as described and illustrated in the diagrams.

11512. "Improvements in collectors or brushes used in electrical locomotion." H. BARCROFT. Dated September 10. 8d. Instead of employing springs as heretofore practised, the inventor attaches an arm of metal by a hinge or free joint to the carriage by means of a bracket or other convenient connection. The arm rests on the charged rail and maintains its contact therewith longitudinally by its own weight, the range of its motion on the hinge or joint being regulated by stops or pins. The claims are 2 in number.

11660. "Improvements in telephonic instruments." A. J. BOULT. (Communicated from abroad by J. C. Reiff, of New York.) Dated September 14. 8d. The inventor uses for an armature a short thick piece of iron; this mass is secured to a very light, elastic support, in order that the support may offer very little resistance to the attraction of the magnet. He uses for a tympan or sounding board a thin sheet of wood, cardboard, celluloid, glass, horn, ivory, bone, cork, mica, vulcanite, brass, or equivalent materials. The claims are 9 in number.

11662. "Improvements in telephonic instruments." A. J. BOULT. (Communicated from abroad by J. C. Reiff, of New York.) Dated September 14. 8d. The inventor makes use of intermittent pulsations of electricity in contradistinction to undulatory currents of electricity for the transmission of sounds, musical, vocal, articulate, simple, or compound, and he employs a method and apparatus for causing makes-and-breaks in an electric circuit, whereby are sent into the circuit intermittent pulsations of electricity, having all the qualities essential for the reproduction of articulate speech. The claims are 11 in number.

11834. "An improved primary battery." C. E. O'KEENAN. Dated September 17. 11d. The inventor makes use of the metallic solution produced to cause, first, the outflow or discharge of that part of it that is too much saturated, i.e., worn out; second, the introduction of new liquid. The claims are 9 in number.

12420. "Improved combined thermo-electrical and hydraulic apparatus for automatically operating air and water valves and the like." B. BOOTHROYD. Dated September 30. 8d. Claims:—1. In thermo-electric or combined thermo-electric and hydraulic apparatus for the automatic actuation of air and water valves or other similar apparatus capable of such automatic actuation, the employment of an electro-magnet with an armature provided with a catch normally locking a disc or other rotating part but adapted to release same at the times and for the purposes set forth, the said actions being effected by the means described with reference to the drawings. 2. In combination with the wheel or other rotating part the adaptation and location of the automatic cut-out and the circuit arrangement as and for the purposes shown and described with reference to the drawings. 3. The general combination of parts constituting the improved combined thermo-electrical and hydraulic apparatus for automatically operating air and water valves and the like, substantially as and for the purpose set forth and described and illustrated with reference to the drawings.

12531. "Improvements in and connected with appliances for the distribution and transformation of electric energy." R. DICK and RANKIN KENNEDY. Dated October 2. 8d. Claim: A transformer of alternating currents of electric energy, for transforming currents of high potential into currents of low potential, and *vice versâ*, comprising a shuttle or double T-shaped core or internal magnetic soft iron portion, either made solid or of thin insulated plates, having coils of primary and secondary conductors wound round it, and surrounded by an outer wire sheathing, all substantially as and for the purposes herein described, in reference to and shown in the drawings.

13563. "Improved electrical measuring instruments." E. W. LANCASTER. Dated October 23. 8d. Consists of a solenoid or electro-magnet of suitable size and construction, with a fixed hollow core of brass, iron, or other metal, or of pieces or a mixture of different metal. Inside this core is suspended or held in position by means of a cord of suitable material, or by other means, a piece of metal (soft iron or steel), being such that it is easily and quickly magnetised to saturation on a current of electricity passing through the coils of the electro-magnet. A second cord or a continuation of the first is passed round the shaft or spindle in a second groove or round a second grooved wheel on the spindle, the groove or wheel being made larger or smaller than the first, if necessary. The end of the second cord or the continuation of the first is then carried to a spring or a counterpoise (quadrant or otherwise) which controls the movement of the spindle. A hand or pointer is fixed to the shaft or spindle, and behind this is placed a dial or card, suitably divided to indicate the units required in the various measuring instruments. The claims are 2 in number.

13648. "An improvement in the manufacture of carbons for electrical and other purposes." W. R. JOHNSTON. Dated October 25. 4d. Consists in the use of paper pulp which may be that made from textile or other fibre or from straw, wood, or other vegetable materials. This is moulded while in a soft, moist condition into the desired forms, subjecting it when necessary to pressure, and then dried and carbonised in the usual way. There is 1 claim.

13712. "An improvement in dynamo-electric machines." A. M. CLARK. (Communicated from abroad by the Electrotechnische Fabrik of Cannstatt, Germany.) Dated October 26. 6d. Claim:—The described means whereby the current may be taken from a dynamo machine in whichever direction it may be running, such means consisting of contact brushes mounted upon sleeves free to be rotated about the machine axis by the frictional contact of the brushes on the commutator, the motion being limited by stops so that the brushes will occupy the most favourable position, and will at same time be switched by contact segments connected to the sleeve, sliding under the contact springs, so that the poles of the machine remain unchanged, substantially as set forth.

13989. "An electric motor." J. B. DENIS. Dated October 30. 8d. The motor proper is of annular form and is composed of sections, in each of which are two wheels made of soft iron or smooth steel; these wheels are constructed of a series of U's of soft iron or smooth steel. There is 1 claim.

16810. "Improvements in galvanic elements." T. GOODMAN. (Communicated from abroad by Dr. C. Gassner (the younger), of Germany.) Dated December 22. 4d. Consists in applying protoxide of zinc as an addition to an agitating or exciting mass for dry elements, such mass composed of exciting salts and plaster powder. There is 1 claim.

14983A. Improvements applicable to mechanical devices which are periodically started by means of electricity." E. W. SERRELL. Dated November 18. 8d. This invention comprises a general arrangement of parts and contrivances which may be used conjointly with the contact device described in the inventor's application of even date herewith, numbered 14,983, or may be used separately in combination with any ordinary contact closing device. The general arrangement comprises a clutch, set in movement whenever a contact is closed, and which, by means of special dispositions, is particularly adapted to working with the special contact described in the aforesaid application, No. 14,983. The The device consists principally of:—(*a.*) A clutch which is started immediately upon the establishment of any suitable contact. (*b.*) A commutator operated by the said clutch, for breaking the circuit so as to allow the contact pieces to separate, when this kind of contact is used, and (*c*) of means for bringing the clutch to a standstill after it has performed its work and the parts have returned to their first position. The claims are 4 in number.

CORRESPONDENCE.

The Proposed Association.

I am one of those who think the formation of an electrical association somewhat premature, and I have formed my opinion from observations extending over a period of five or six years, and also from the correspondence at present proceeding in your columns, and those of your contemporaries.

Some gentlemen have passed over Mr. Rawson's letter as unworthy of serious attention, but in reality it should be considered the most valuable contribution to the correspondence. An association formed on the lines indicated would fail to command that confidence necessary for its success, because of the terrible want of mutual trust between members of the trade; of the unfair dealing; of the dishonesty; of the wholesale corruption which prevails. If proof of this were wanting, we have the testimony of Mr. Rawson's letter; for if he had no knowledge of the ugly facts enumerated in his list of points he recommends the new society to make special objects of its care, how could he name them?

We know how terribly public confidence has been shaken in all electrical undertakings. And why? The answer is supplied in the report of a public meeting contained in your present issue. All who read that brief report must inevitably come to the conclusion that neither the chairman nor the other director present was very candid in the replies they gave to a shareholder who sought to obtain the most ordinary information. My own impression was that the shareholders were being hoodwinked, and another shock was being administered to the already tottering public opinion.

Who forces down prices? Why, the very people who cry out against it. It is a common thing to hear these people inveighing against what they term the rascality of small traders manufacturing inferior goods and under selling them. Yet it is they themselves who by their unfairness compel the small traders to sell at a low price. If you introduce anything new or improved to the trade, the first thing they insist upon as a condition of their taking it up, is that your price must be below anything of the same class already in the market. This in addition to demanding a most unreasonable discount. Then, as if they wished to bleed you to the very death, they will not give you a settlement of your account, but require you to square it by giving them orders to the amount. "Registration of black sheep"—wouldn't it do our eyes good to see a list of the names of the *real* black sheep, and know they had been caught and branded! But many would be terribly surprised to find their names there, having always flattered themselves that they were effectually deceiving the public, and being looked upon as most honourable members of their trade.

As to the prevalence of blackmailing in the trade, it has assumed such tremendous proportions that it behoves every principal to be constantly on the watch to detect it among his staff. Seldom indeed in transactions with the trade is the commission shown in your books the only discount you have been obliged to deduct from your sale price. Sad, too, is it to know that it it is not so often the subordinates, but the heads of the staff who levy the black mail.

A last point, and one which ought to have had a prominent place in Mr. Rawson's list, the system of intimidation with regard to patents which is so largely practised by persons who chance to have rivals in some special line of the business. One instance of this is so glaring in London that many of your readers must be acquainted with it.

My firm has had experience of this, and I hope the people who were guilty of such mean criminality will read this letter and take warning, for a repetition of such conduct will place them in the position of defendants in an action for libel and intimidation.

Let the trade first see that its own house is in order before clamouring for the formation of a society to protect its interests against external dangers.

In conclusion, I must ask your indulgence, and beg of you to excuse me signing my name to this letter as I should assuredly be boycotted in my business if I revealed my identity.

Pro Bono Publico.

November 8th, 1887.

The Water Primary Battery.

The explanation you ask for in your issue of October 28th is as follows:—

Early in 1884 M. D'Humy asked me, as a friend, to look at a form of cell which he stated was his own invention. I thought the results he claimed were interesting and likely to be valuable for private electric lighting on a small scale. At that time ($3\frac{1}{2}$ years ago) such lighting by primary batteries appeared likely to be in demand wherever wealthy customers were anxious to have the light and where cost was no object.

The letter I then wrote to him, a translation of which is given in your number, was in no sense a report; it was only a friendly and quite private reply to his question, to encourage him to work the matter to a practical result. You will notice that in that letter I say that the capital required for the purpose need not be considerable.

I am advised, therefore, that the use of this private letter by M. D'Humy in connection with the formation of a large company in England after such a long lapse of time, and without any permission from me, is not justified, as I have already stated to Mr. Crompton.

D. Monnier.

Vienna, *November 3rd*, 1887.

Transformer Working.

With reference to Mr. Addenbrooke's remarks in your last issue on the subject of the danger of a contact in transformers between the primary and secondary circuits, will you allow me to say that I hope shortly to get out a very simple apparatus for obviating this.

P. Cardew.

November 8th, 1887.

Primary Batteries for House Lighting.

In the discussion which followed Mr. Perry Nursey's extremely interesting paper on primary batteries before the Society of Engineers last Monday, we were favoured with the usual professional comparison between the cost of coal and that of zinc, with the seemingly inevitable inference, inseparable from such discussions: "*Ergo*, primary batteries cannot possibly compete with dynamos and steam engines." A few figures will, however, suffice to prove that such an inference is erroneous.

1. When burning coal, even at the low rate of 4 lbs. per H.P. per hour, a steam engine is only utilising less

than $\frac{1}{18}$th part of the theoretical heating power of the coal, for 1 H.P. (as defined by Watt) is equal to 33,000 foot-pounds per minute, whereas the theoretical power of 1 lb. of coal is 10,500 (heat units) × 772 (Joule's equivalent) = 8,106,000 foot-pounds, and $\frac{4 \times 8{,}106{,}000}{60 \times 33{,}000} = 16{\cdot}37$; a formula which to most of your readers will be perfectly familiar.

2. At 17s. per ton, one penny will purchase rather more than 10 lbs. of coal, so that the value of the 4 lbs. of coal is $\frac{2}{5}$ths of one penny. How is it that the theorisers do not go a step further and consider that their comparison of the cost of primary batteries with dynamos worked by steam or gas and accumulators would only hold good if the entire cost of that combination were represented by this $\frac{2}{5}$ths of a penny per hour, or say 2d. for the average lighting day of five hours? The wages of one mechanic to attend to the engine and dynamo, keep in order and renew the brushes, &c., alone amount in small installations to more than the whole cost involved in the use of a primary battery. Moreover, one horse-power per hour produced from a steam engine does not supply anything approaching one electrical H.P. of 746 watts; at the South Kensington Exhibitions the engines practically supplied on the average less than half that quantity of electricity in the lamps. The same is produced from one pound of zinc, costing 2d., working noiselessly, steadily, and without any attention, in a primary battery.

3. With regard to gas, one ton of coal makes 10,000 cubic feet, and, at 3s. per 1,000 cubic feet, costs the consumer 30s. Then, 4 lbs. of coal converted into gas produce 18 cubic feet, which, with gas of 15-candle power, will give light equal to 54 candles when burnt in the standard "London Referee" argand burner. The ton of zinc costs eleven times as much as 30s., but, on the other hand, 4 lbs. of zinc in a primary battery supplies 1,490 watts (2 H.P.), or sufficient electrical power for 24 lamps of 20-candles (each of 62 watts), or 480 candles, and, weight for weight, nearly nine times as much light as that obtained from 4 lbs. of coal converted into gas and burnt under the most favourable conditions.

These figures, which any of your readers is quite quite competent to check, conclusively disprove the, *a priori*, contention that the applicability of primary batteries to house lighting is disposed of by the comparative cost of zinc and coal. Questions of mechanical detail, compactness of form, quantity and constancy of current, and, above all, the reduction of trouble to domestic servants by simple arrangements of manipulation, are points of more importance; but, judging from my own experience, none of them appear to be such as need stand in the way of the future employment of primary batteries as the solution of the question of house-lighting by electricity.

O. C. D. Ross, *M.Inst. C.E.*

Ayrton's "Practical Electricity."

Could you explain to me the following difficulty. In Ayrton's "Practical Electricity" it is laid down that the P.D. at any two points of a circuit equals the current multiplied by the resistance, *i.e.*, $V = A\ r$ for the external resistance where r is the external resistance, and V the P.D. at ends of the external resistance; also $v = A\ b$ where v is the P.D. at the terminals of the battery and b the resistance of the battery; also $V + v = E$.

In example 46, p. 207,

$$V = \tfrac{1}{2} \times 25 = 12\tfrac{1}{2},$$

and

$$v = \tfrac{1}{2} \times 5 = 2\tfrac{1}{2},$$

and

$$V + v = 15 = E.$$

What I want to know is how V can be $12\frac{1}{2}$ and v $2\frac{1}{2}$, since the terminals of the battery are joined to the terminals of the external resistance, and the P.D's. between the terminals of the battery and of the external resistance appear to me to be necessarily the same.

A. J.

[Our correspondent has attributed to Prof. Ayrton statements which were never made; there is no paragraph in "Practical Electricity" to the effect that "$v = A\ b$ where v is the P.D. at the terminals of the battery and b the resistance of the battery." The mistake that "A. J." has made is in assuming that the law

Potential difference = current × resistance

holds good *when there is an electromotive force existing in the resistance*, an assumption which is quite incorrect. The true law in such a case is

$$v = A\ b \pm E,$$

where E is the electromotive force existing in b, the value of E being *negative* if E acts *with* the current, and *positive* if it *opposes* it (the latter being the case when, for instance, a strong battery forces a current back through a weaker one, the potential difference, v, being that between the terminals of the weaker battery). A full explanation of the laws will be found given in pages 292–295 of Kempe's "Handbook of Electrical Testing" (Fourth edition). We may remark that our correspondent's mistake is not an unnatural one, as the law "If V be the potential difference that would send a current of A ampères through r ohms then,

$$A = \frac{V}{r},"$$

ought to be given as "If V be the potential difference that would send a current of A ampères through a resistance of r ohms *in which no electromotive force exists*, then

$$A = \frac{V}{r}."$$

—EDS. ELEC. REV.]

Telephones.

Experience has taught me that a controversy carried on in a newspaper seldom, if ever, results in convincing the controversialists of the correctness of the *opinions* advanced by each. *Facts* stated and substantiated by proofs cited sometimes are accepted by both controversialists and generally by the public.

In making a few remarks upon the statements made in the letter of your amiable correspondent Mr. J. S. Ross in the REVIEW of 14th inst., I shall neither refer to any opinions expressed by him or by myself in our controversy, but shall, in the first place, correct what you, Messrs. Editors, must have been convinced was a typographical error in my letter published in the REVIEW of September 9th, to which Mr. Ross refers in his letter in the REVIEW of October 14th. In my letter above referred to, as published in the REVIEW, I am made to say that Sir George Jessel holds the Glasgow receiver to be an anticipation of Bell's receiver with the disc held down all around its circumference. The word "*not*" was in my original copy from which the type-written copy which I sent you was made, as I find it in my original copy now before me. My many letters in the REVIEW present evidence that I had always stated that fact.

In regard to the "Glasgow receiver," Mr. Justice Fry, in his judgment in the Cox-Walker case, used the following language: "That the Glasgow receiver can now be made to speak, though not very distinctly, I know from what has taken place in this Court, because I have heard it." "A Hunnings transmitter with seven separate cells was used."

Lord Justice Bowen in the judgment by him in the appeal case used the following language: "It was argued in the Court below and was contended at one time before us, that the Glasgow receiver, as shown at Glasgow, was of no utility. I think that was a false point, because we have seen it work and know that it

works well; we know now that it is not true that the Glasgow instrument cannot be made to speak even in its present shape."

Mr. Ross says that "their lordships heard faint sounds and rumblings." That is true, but then the Bell receiver was used as a transmitter; but when the Hunnings transmitter was used the Glasgow receiver acted well.

In my opinion the principal reason why the Glasgow receiver is not used in England, is because the Hunnings and all other good carbon transmitters are covered by Edison's patent.

Mr. Ross asks me, "whether it is not a little sad to see Barney's letter on the Bonta telephones, for Mr. Barney has *himself* an instrument which also *professes* to work on the pulsating system."

I confess I am so obtuse as not to know any reason why I should not examine, investigate and test any instrument which is offered to the public which the inventor claims to work on a new principle, especially as the new principle claimed presents the very greatest claim to investigators in scientific and practicable matters.

Is it possible because I have invented an instrument which "*professes*" to work on the pulsating system that I should be precluded from expressing opinions upon other inventions.

The quotations I made about the Bonta telephone from his patents and from the prospectus of his company are correct, and you, Messrs. Editors, can satisfy Mr. Ross of that fact.

If Mr. Ross will take the trouble, purely in the interest of science, to examine my English patent No. 11,660, September 14th, 1886, he will probably be able to form a correct judgment regarding it, and I think he cannot fail to be convinced that the tympan *must* be vibrated by the impact of air waves, and that in its vibrations it *must* alternately *make* and *break* contacts, first on one side, and afterwards on the other side of the tympan. The construction of the instrument establishes that fact.

Now as to its capacity to transmit impulses of electricity which will cause words and sentences spoken into it to be repeated by a good magneto-receiver, all I can say is that many persons have tested it, among whom were Profs. P. H. Vander Weyde and Morton, both of whom have made affidavits that the instrument, when adjusted as described in the patent, that is when none of the electrodes are in contact, does cause the words and sentences spoken into it to be reproduced with clearness and distinctness.

W. C. Barney.

New York, *October 28th.*

Underground Conductors.

Far from intending to bring the wrath of Mr. T. O. Callender on my shoulders, I thought that by accepting his proposal to furnish data with regard to his underground system, I was actually placing in his hands an excellent opportunity of disproving the unfavourable opinion held by many electrical engineers as to the efficacy of his system.

Mr. T. O. Callender, in your issue of November 4th, is pleased to deny the accuracy of my statements, and refuses to give the information which, in his letter of September 30th, he offered to supply. In this letter Mr. Callender expresses himself as follows: "As a matter of fact, nearly all the underground mains in use up to the present time for public or private lighting are of our make, *and I can give* some hundreds of instances where our cables have been so employed with perfect success."

Now, without doubting that the Callender system has obtained a certain amount of success (as I have already admitted), I asked Mr. Callender, on October 14th, to substantiate his statement. In answer to this very natural demand he replies, in your issue of November 4th: "With reference to work done by us in this country and elsewhere, full particulars are and always have been in the hands of the trade, and are never refused to any persons having a right to obtain them, but I certainly have neither the time nor the inclination to gratify the curiosity of anyone who hides his identity under an initial."

Now, without desiring to question Mr. Callender's good faith, this rejoinder strikes one, to say the least, as being rather evasive. Why should those "in the trade" be the only ones favoured with the very interesting information which Mr. Callender doubtlessly could supply? Who are those lucky persons "having a right" to obtain the particulars which Mr. Callender refuses to the unknown quantity, "W."?

Why should Mr. Callender discuss the question with "W." up to a certain point, and then when asked to supply information offered, refuse to fulfil this offer, because, forsooth, his opponent in the discussion still writes under the same initial as employed by him from the first? Truly I am unfortunate, for it seems that everyone excepting poor "W." is to be granted the desired facilities.

Mr. Callender must see that he has prejudiced his position in what I hoped might have proved an amicable discussion. I have solicited no controversy, but I should have been glad to see some details of the Callender process which would have allayed certain fears and removed certain doubts as to the efficiency of the system. Mr. Callender, from the first, might have refused to argue with an anonymous writer, but it is now rather late in the day for him to adopt "Right about, face!" tactics, on the score of my anonymity.

As to the Antwerp installation. Would Mr. Callender inform me to what extent the underground system in that city was actually employed for electric lighting purposes? It would be also interesting to learn Mr. Callender's views as to the results of tests taken about two years after the system had been laid down. My want of success in approaching Mr. Callender upon the subject of the general employment of his system leads me, however, to entertain no very sanguine expectations of receiving a satisfactory reply as to the tests.

With regard to the American underground systems, I do not see that Mr. Callender has in any way refuted the validity of my statements. I do not pretend to have that intimate acquaintance with electric lighting installations in that country which Mr. Callender doubtlessly possesses, but one can fairly judge as to the condition of affairs by the published reports, and it is a waste of energy on your correspondent's part to attempt a denial of what has actually occurred. Mr. Callender, I fancy to some extent, contradicts himself with regard to arc wires. In one paragraph he states that electrical engineers in the United States are utterly opposed to placing the arc wires underground, and a little further on he says that it is merely a question of time for those wires to be buried, presumably on the adoption of the Callender system, at least this is the inference.

With reference to the Edison tubes, I would ask Mr. Callender to read the paper and subsequent discussion referred to by Mr. Charles Bright. He will find that no mention is made as to the composition of the insulating material employed. We are certainly told that the wires are led through a pipe, that they are served so as to prevent contact with one another, and *that an insulating compound is then run into the pipe.* This is all, the most important factor, in my opinion, being ignored.

I have no interest in either writing against the Callender system, or in advocating any other, but I have the wish to ascertain whether various defects which I believe inherent to certain systems, have a reality or are merely theoretic.

My statement of opinion in one direction, and Mr. Callender's expression of diametrically opposite views, scarcely seems to lead to any very profitable end. This is all the more to be regretted since Mr. Callender is surely in the best possible position for proving his contention.

W.